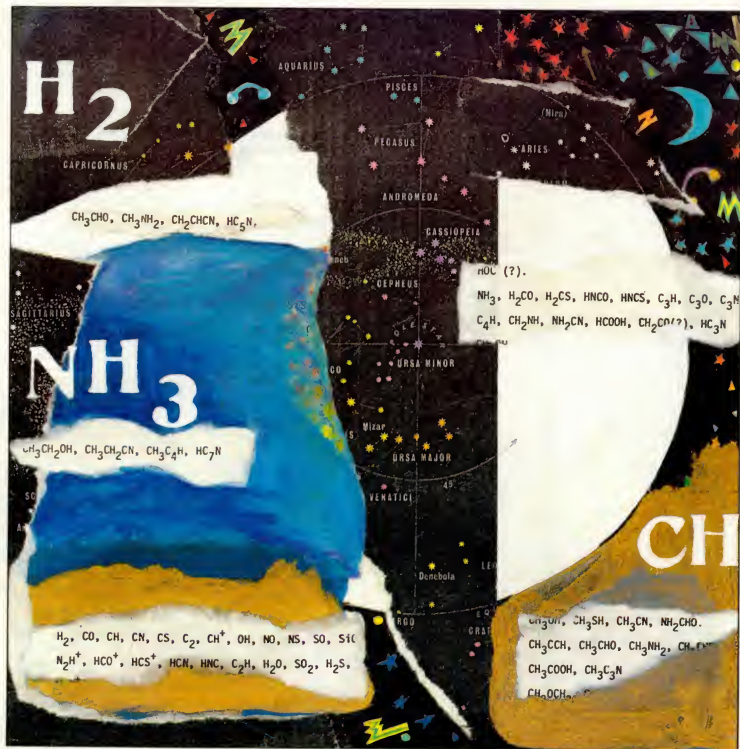


# newscientist

## CHEMISTRY BETWEEN THE STARS



The future of data storage  
Parallel lines converge in geometry

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To mark the 200th anniversary of the birth of the Frenchman who became America's most celebrated illustrator of natural history, *New Scientist* is reproducing, in poster form (297mm x 420mm), four of John James Audubon's most notable illustrations of New World birds and mammals. Each copy of the 25 April issue of the journal will include, free, one of these magnificent illustrations in full colour, plus the chance to purchase the other three.

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25 April 1985 No 1453 Weekly £1.00

## newscientist



FROM early in the 18th century, the Royal Society of London was actively encouraging visitors and settlers in the New World to record their findings. It was in this tradition that the Haitian-born Audubon provided unique folios of first the birds of America and subsequently the quadrupeds (the mammals and rodents etc) of North America. He broke new ground in painting his birds at life size. He also kept careful notebooks of what he saw.

By 1823 Audubon thought his work was ready for publication. Unable to persuade a publisher in the United States to take on the task, he set off for Europe confident that he would find someone who would value his work. His assessment of his own ability was vindicated in Edinburgh, Manchester, London and Paris (he was soon elected to fellowship of Royal Societies of London and Edinburgh). Eventually, he found an English printer prepared to extend the credit necessary to complete the production of *The Birds of America*. Publication of the 435 plates took more than a decade. During that time, the artist and his agent sought out a thousand subscribers prepared to pay \$1000 each for a complete set. When a set of *The Birds of America* came under the auctioneer's hammer at Sotheby's, in 1984, it raised £1.1 million.

Watch out for this cover of *New Scientist* on 25 April. To prevent disappointment in missing this special offer, place your order now with your newsagent. Our cover will feature the snowy heron. Inside will be your FREE Audubon poster, one of those shown inset. You will also be able to order the other three Audubon posters, single copies of your favourite, or the full set of four.



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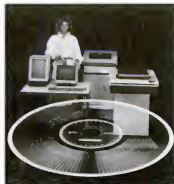


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### Technology of turbulence The golden age of mathematics

Sir Hanley/Dorcas Mur

newscientist



# Research and the embryo

Sir Andrew Huxley

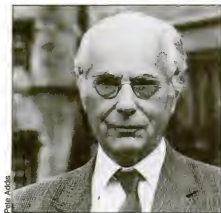
**I**F IT BECOMES law, Enoch Powell's Unborn Children (Protection) Bill is likely to prevent any research being undertaken on human embryonic material. On the other hand, the Warnock committee recommended that such research should be permitted but only within a strict time limit from the time of conception and under regulation by an official overseeing body. In judging the relative merits of these two positions it should be realised that research on the earliest stages of development of the fertilised human egg has already yielded substantial benefits in the treatment of infertility, a condition that affects about 10 per cent of married couples in this country, and that such research has the potential to give information of immense value for the reduction of inherited disease and for understanding how rubella and other viruses damage the embryo.

Unfortunately, the public debate on such questions is taking place against a background of widespread ignorance about the earliest stages of development of the fertilised egg, although the Warnock report itself contains an excellent two-page account of the stages through which development passes. This ignorance causes much confusion, which is made worse by an unfortunate ambiguity in the word "embryo".

From about eight weeks after fertilisation, the developing human organism is known as a "fetus". By that time, the parts of the body and the major internal organs are recognisable. During the previous six weeks or so, while the parts and organs are successively making their appearance, the word "embryo" is used for the developing organism. This is the sense in which the word "embryo" is generally understood, in contradistinction to "extra-embryonic" tissues which, like the embryo itself, are composed of cells descended from the fertilised egg, but which—unlike the embryo proper—are destined to form part of the placenta and the membranes that surround the fetus.

The ambiguity arises because the word "embryo" is also used to denote the whole of the collection of cells formed by repeated division of the fertilised egg during the first two weeks or so, although only a few per cent of these cells are destined to become the embryo proper; by far the greater number of them will turn into extra-embryonic tissue and ultimately into the structures that are discarded as the afterbirth. Furthermore, it is indeterminate which particular cells will form the embryo proper.

The embryo proper is first recognisable



Phil Adams

sense in which the word is generally understood, and later again a "fetus".

The Warnock committee recommended that research on human "embryos" should be permitted up to but not beyond the 14th day after fertilisation, that is, only before the development of even the first sign of the definitive embryo.

The limitation on research proposed by the Warnock committee is therefore not an "arbitrary" limit as was repeatedly said in the recent debate on the report in the House of Lords. It is explicitly related to a very fundamental event in early development—the first appearance of what is ordinarily meant by the word "embryo". That is not the same thing as saying that it is the correct point during development to select as the limit beyond which no research should be permitted. On the one hand, 3 of the 16 members of the committee signed an "expression of dissent", appended to the report, recommending that experimentation should not be permitted at any time after fertilisation. On the other hand it can be argued that the limit should be set at some stage of development of the nervous system: even the first appearance of the tubular structure that later develops into the spinal cord and brain does not take place until about a week after the appearance of the "primitive streak".

A related question is whether the legal limit should be set in terms of time after fertilisation (as proposed in the Warnock report) or in terms of degree of development. A fertilised egg cultured outside the body tends to develop more slowly than during normal development in the uterus and, unless special conditions are employed, does not maintain the organisation necessary for formation of a primitive streak; hence, culture could be permitted well beyond the 14-day limit without risk of formation of a definitive embryo.

It is important that these features of the early stages of development be borne in mind in any discussion of the rights and wrongs of permitting research on human embryonic material, and most of all when legislation on such matters is being debated in parliament. □

Sir Andrew Huxley is President of the Royal Society and a winner of the Nobel Prize for Physiology or Medicine.

at about the 15th day after fertilisation, when a specialised region of cells called the "primitive streak" first appears. Before that stage, it cannot be said that a definitive embryo exists; the product of conception is a structure of which a small and undetermined part will—if development proceeds normally—form a "primitive streak", and later an "embryo" in the

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## THIS WEEK

## Does the answer lie in the soil?

THE THEORY that life originated from clay received support in California last week. Scientists at NASA's Ames Research Center reported that clays can perform two of the basic processes that are essential to living organisms—the storage and transfer of energy. These characteristics do not prove the theory, but they are necessary conditions for it to be correct.

The research adds to a growing controversy within science. The clay theory is being advanced as an alternative to the classical view that life evolved from a "primordial soup" of gases, water and energy.

According to the theory, clay has the ability to act as a matrix for the creation of the earliest forms of life. Clay minerals supposedly served as inorganic forerunners to later organisms that were based on organic compounds.

For more than 50 years, most scientists have accepted the idea that life began from a random mixing of simple organic molecules in the primordial soup of the Earth's primitive oceans and lakes. Atmospheric gases—ammonia, methane, and nitrogen—dissolved in water and formed more complex molecules using energy from lightning or the Sun's ultraviolet rays.

However, some scientists now doubt that there was enough ammonia and methane in the Earth's early atmosphere to permit the formation of complex molecules. The two gases would have been destroyed by ultraviolet light from the Sun, they argue.

The "life-from-clay" theory has been proposed by Graham Cairns-Smith from the University of Glasgow, as an alternative. But his ideas have lacked hard experimental evidence, until now. Interest in Cairns-Smith's theory will be rekindled because of the work at Ames, which was led by Lelia Coyne, a chemist from San José State University.

Ian Anderson, San Francisco

The research indicated that clays could absorb energy in either mechanical or electromagnetic form and then release it slowly over periods lasting up to several days. Coyne tested dozens of clays, but the best results were obtained using kaolin clays from St Austell in Cornwall.

When the clays were wetted, dried, pulverised, fractured or irradiated with gamma rays, they emitted ultraviolet light. The slow release of the light indicated that energy was being stored. Coyne believes that irregularities or defects in the structure of the clay permitted the temporary capture of particles of light energy called photons.

The natural forces needed to trigger the storage and release of energy include earthquakes, erosion, tidal cycles, and seasonal

freezing and thawing, Coyne said.

The work also indicated a way in which clays could create proteins, one of the basic building blocks of living organisms. The formation of small proteins from amino acids could have been speeded up when the clay catalyst was irradiated before the reaction.

But the research leaves unanswered the question of how much energy can be stored by clay and whether or not it is sufficient to drive chemical reactions. Cairns-Smith, who was at Ames last week, said experiments were needed to determine how much information was stored by clays and whether or not they could be regarded as genetic materials. Coyne said that other minerals could have similar properties to clay and might have contributed to the chemical processes that created life. □

## The conundrum of the Channel link

IF THE Channel is ever spanned by a bridge, then the French will drive on the right and the British on the left. This novel compromise appears in the specification that builders of a Channel link must follow. *The Invitation to Promoters*, as it is called, was published last week by the French and British governments.

The document says: "For safety reasons, it would appear desirable for the transition from the general traffic rules applicable in France to those applicable in Great Britain, or vice versa, to take place as the user leaves the link." The French version is identical, except that it is written in French. The report, which was drawn up by a joint working party of the two governments, lays down the technical and financial conditions for building a Channel crossing. A key technical specification for any bridge is that the superstructure must be able to withstand collision with a vessel travelling at 17 knots. It is unlikely that any of the three designs for a Channel link that include bridges could meet this condition, without considerable strengthening of their piers.

The two leading schemes are the Channel Tunnel Group's plan for two 7-metre diameter tunnels for railway trains and a scheme proposed by the consortium called Euroroute. This scheme is a combined bridge and tunnel, it has a road bridge linking two artificial islands to each coast, and a tunnel under the central section of the Channel, combined with a railway tunnel. All links will have to be designed to have a life of 120 years, a target which is likely to prove more difficult for schemes including



Shakespeare Cliffs, Dover: no longer the end of the line

a bridge. In the tunnel, cars would be carried across by trains for safety reasons.

The trains are likely to have two engines, an electric motor to run in normal circumstances, but also a back-up engine, probably running on diesel so that if the electricity fails the tunnel can be evacuated in 90 minutes.

Promoters with novel construction techniques, and that is likely to include all except the twin-bore tunnel, will have to subject these techniques to independent vetting. The promoters will also have to draw up an environmental impact statement.

Promoters will have to provide details of their financial backing, traffic forecasts and expected income. Neither government will provide any financial support for the scheme, and there will be no duty-free sales. Promoters have to complete their proposals by the end of October, and the governments will make a decision by the end of the year. So that the governments are not deluged with frivolous proposals promoters will have to place a £175 000 bond with the governments. The losers will have their money returned; the winner will have to pay a further deposit. □

OBSERVER David Austin

NASA

TEST-TUBE BABY  
KIT



LIFE-FROM-CLAY INC.

CONTAINS CLAY AND  
LIFE-GIVING PROTEINS

AusL

## Uncharted pipe could explain Bhopal disaster

Debora MacKenzie, Geneva

PEOPLE in Bhopal, India, ran through the streets in panic again last week, as clouds of noxious vapour, this time chlorine gas, leaked from Union Carbide's chemical factory. The chlorine leaked from a plant manufacturing phosgene. There were no casualties.

The incident renewed concern about whether the accidental release of methyl isocyanate (MIC) from the plant last December, which killed over 2500 people, was caused by "unique, unusual" events, as Carbide's US headquarters claims (*New Scientist*, 28 March, p 3).

A report by Indian scientists, prepared for a judicial inquiry, blames the disaster on flaws in the plant's design as well as operating errors by local staff. Meanwhile, a detailed analysis of factory specifications, released in Carbide's own report on the accident, reveals new evidence that safety systems at the plant were inadequate to contain such a reaction.

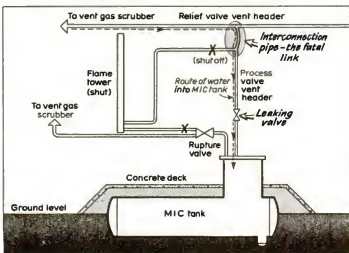
Two Indian scientists investigating the disaster believe they now know how water got into an MIC storage tank to set off the runaway reaction that led to the disaster. Bharat Bhushan and Arun Subramanian have published their findings in the journal *Business India*. They say the water got in through a temporary pipe installed between two hitherto unconnected parts of the MIC equipment. They say that the parent company in the US had given permission for the tank. Yet the company's own report on the accident makes no reference to the pipe and it does not appear on the company's diagrams.

The extra pipe connected the relief valve vent header, through which pipes from several systems send excess chemical fumes to a gas scrubber, to the process vent header, a pipe that led directly into the MIC tank (see diagram). The pipe was installed as a bypass, to connect the MIC tank with the relief system during closure of the process vent header. This closure was necessary while the flare tower, another safety system meant to burn excess gas, was closed for repairs.

On the evening before the accident, engineers flushed water through four pipes leading from other equipment into the relief valve vent header. When the operators opened valves to let the water out, two valves were completely blocked and two more were partly blocked. Water accumulated in the relief valve vent header.

Operators stopped washing the pipes when they noticed that no water was emerging through the valves, but started again a few minutes later on orders from the supervisor of the MIC plant.

The water in the relief valve vent header would have been safe enough, had it not been able to flow down through the new bypass pipe into the MIC pipes. Even then a valve at the entrance to the MIC tank should have stopped the water entering the tank. But that valve was either open or leaking (*New Scientist*, 28 March, p 3). So



Fatal links in a botched-up system

there was nothing to stop water trapped in the relief valve vent header from flowing into the MIC tank.

The valves were blocked and leaking because of negligent maintenance in Bhopal, say the scientists. But the installation of the bypass line, a key factor in the accident, was approved by head office.

Blame also attaches to head office over the issue of whether Union Carbide should have equipped the tank with safety systems to contain a runaway reaction of the kind that overwhelmed the plant.

It has been difficult for scientists investigating the accident to get details of the safety features of the Bhopal plant from Union Carbide. But now Ian Swift, a British consulting engineer working in the US on the safety of chemical plants, has calculated the size of the safety

vent in the MIC tank.

Using Carbide's own estimates of the rate at which polymerising MIC rushed out on the night of the accident, Swift says the vent was probably no larger than 22 square centimetres. This is a standard size used in chemical equipment and would have been sufficient to release escaping gases alone. But, according to Carbide's report, the polymerisation of MIC resulted in the bubbling out of liquids and solids as well as gases. A vent large enough to handle such a flow at the release pressure used in Bhopal, would have had to have measured 200 square centimetres, says Swift.

Swift is not saying that Carbide should necessarily have used such a huge vent. But he says it does show that the conditions that Carbide expected the safety system to face did not extend to runaway polymerisation reactions. This is odd because such reactions were known to occur in MIC when the plant was designed.

Jackson Browning, Carbide's vice-president for health, safety and the environment, is currently changing the release system on the MIC tanks at a similar plant at Institute, West Virginia. This is being done in such a way that the plant can now handle flow containing solids and liquids as well as gases.

The changes will include fitting larger diameter safety valves and a lowering of the pressure settings on the safety valves from 40 pounds per square inch (psi) to 15 psi. At this lower pressure, any reaction will still be going slowly enough for vapourisation to absorb enough energy to damp down the reaction, engineers believe. □

## Canal lift that needs a face-lift

THE BRITISH Waterways Board will have to spend nearly £600 000 if the unique Anderton lift is to work again. The lift connects the Trent and Mersey Canal with the River Weaver Navigation, at Anderton in Cheshire. It lifts canal boats through 16 metres from one waterway to the other.

The lift, which is 110 years old, is the last surviving mechanical device for raising boats on British canals. It was taken out of service at the end of 1983 for repainting and the removal of rust. During this work, engineers discovered serious corrosion. The British Waterways Board, which runs 3000 kilometres of canals in Britain, is now considering whether to keep the lift as an historic monument or to spend £2½ million to install a modern mechanism.

If the lift is saved it will probably be converted from its existing hydraulic mechanism to electricity. Jeff Hecht, Boston



## Aircraft crash 'was a success'

**A**VIATION FUEL that does not burn in crashes won official backing last week—despite the fact that its most public demonstration ended in a dramatic fireball.

The demonstration, last December, involved crashing a remotely controlled Boeing 720, fuelled with ICI's anti-misting kerosene, into the Californian desert. Unfortunately for ICI, which had spent 17 years developing the fuel, millions of television viewers saw the airliner burst into flames after the "controlled impact" (*New Scientist*, 6 December 1984, p. 5).

Last week, however, the US Federal Aviation Administration, which designed the test, said that the experiment had demonstrated that anti-misting kerosene can make aircraft safer. It also provided valuable data on the behaviour of an aircraft's structure in a crash. Officials are still analysing the nine kilometres of film taken from both inside and outside the aircraft during the crash.

How could the test be a success when the aircraft burst into flames? David Lane, ICI's new-products manager, said last week that the fire had been caused by "a very special combination of factors. If you remove any one, it would have looked totally different." Anti-misting kerosene,

in a crash. Because of the way the Boeing 720 landed, the burning engine lodged under the fuselage as it slid along the ground. Burning fuel then entered the plane's cargo hold through holes punched by sharp obstacles on the runway. This started a secondary fire, which destroyed the aircraft.

"We have never maintained that the Avgard additive can prevent all post-crash fires," Lane said. "It is an anti-misting agent." However, Lane said that the additive would have helped passengers in the doomed jet by staying liquid for far longer than ordinary fuel, so keeping the fuselage cool. "So far as we could judge, it did prevent misting," Lane said. "The only fire started from the cut-open engine." Some would have escaped.

Although ICI is confident about the fuel's future, and the US's Federal Aviation Administration (FAA) agrees that it can make aircraft safer, the world's airlines will not be using it for many years. A Congressional Sub-Committee on Transportation last week ruled that "more analysis is needed before the FAA can take a decision on a notice of proposed rule-making which would make mandatory the use of anti-misting kerosene." Such a

## Smoke gets in your genes

**C**IGARETTE smoke rots your genes—quite literally. Japanese researchers have found that cigarette smoke causes human DNA, the genetic material of all cells, to break up into smaller strands. In experiments, they found that one cigarette can cause about 10,000 single-strand breaks in the DNA of one cultured human cell. They suggest that this "clastogenic" action of breaking DNA strands could be the reason why cigarettes can cause cancer.

The team of researchers, from Tokyo's National Cancer Center Research Institute, says in an article in the current issue of *Nature* that "there has been no previous direct demonstration that cigarette smoke can cause single-strand breaks in DNA". The team suggests that the breaks could be caused by active oxygen (such as hydrogen peroxide and the free oxygen radical,  $O_2$ ) that is generated by cigarette smoke.

"Although, in the body, most [single-strand breaks] caused by cigarette smoke are expected to be efficiently repaired, some would remain unrepaired and the accumulation of such [breaks] over a long period may have serious consequences, especially for heavy smokers," the researchers say. □

## Hydro holdup

**P**LANs for the first new hydroelectric scheme in northern Scotland since the 1960s have been put on ice by ministers. The North of Scotland Hydro-Electric Board wants to build two small power stations on the Grudie and Talladale rivers that drain into Loch Maree in Wester Ross (*New Scientist*, 28 February, p. 8).

The Scottish Office had been considering the plan for two years. The scheme was opposed by local landowners, including the Whitbread brewing family and the Wills tobacco family. But the government says it has stopped the scheme on financial grounds. It says the Hydro Board is already engaged in other capital projects in this remote area of north-west Scotland. These include an 80-kilometre high-voltage powerline along the length of the Isle of Skye and two submarine cables to link the Western Isles to the national grid. □

## Quick as a flash

**T**HE CREATION of the fastest man-made event ever is being claimed by scientists at AT & T Laboratories in New Jersey, US. They have produced a pulse of light lasting just  $8 \times 10^{-15}$  seconds (8 centoseconds or a millionth of a billionth of a second).

Charles Z. Shank and his colleagues passed a pulse of laser light through a short length of optical fibre. After emerging from the fibre, the pulse was reflected back and forth between a pair of diffraction gratings in a way that shortened it. The pulse was only four or five wavelengths of visible light long, or 2-4 micrometres. □

## Statistical accidents

**E**XHORTING the unemployed to "get on their bikes" may not reduce the dole queues—but it might reduce road accidents, according to an article in *Accident Analysis and Prevention*.

Susan Partzky, of the US's National Highway Traffic Safety Administration, has constructed a mathematical model which "explains" the number of deaths on the roads by changes in the number of people in work. This model apparently explains 89 per cent of the variation in road deaths between 1960 and 1982. This correlation is improved to explain a staggering 98 per cent of the variation by the inclusion of a factor to cover the effect of lower speed limits that were introduced in the wake of the fuel crisis of 1974.

Partzky's paper emphasises that the increase in the dole queue does not cause a cut in road deaths. Other experts suggest that it is more likely that the level of unemployment is a convenient economic indicator. If the economy booms, people drink and drive more. □



The moment that the flame retardant worked, according to ICI

which ICI promotes under the name Avgard is a heavy polymer which is mixed with kerosene when aircraft are refuelled.

The agent prevents fuel forming a mist if a tank is ruptured, but would not stop a continuous source of ignition setting fire to the fuel, which happens in the aircraft's engines. Aircraft that run on the fuel have to be fitted with degrading equipment which removes the polymer before fuel enters the combustion chamber.

What happened in the test crash was that a metal obstruction on the ground, designed to rip off a wing during the crash, cut into an engine. This released fuel that had passed through the degrading equipment, as well as volatile hydraulic fluid. The engine's turbines came to a stop from 10,000 rpm in one third of a revolution, generating huge amounts of heat.

Airline engines are designed to shear off

notice would be only the first step in making the additive compulsory. One problem is that, as unmodified planes cannot fly on modified fuel, all the world's airlines would need to change simultaneously.

Another problem is that engine makers will need to carry out further tests to ensure that the degrading equipment is totally reliable. The crash test was the first time that an airliner had flown on the fuel. Previous tests on a plane with only one engine modified have clocked up less than 50 hours flying time.

But the main problem, Lane concedes, is that following the test crash "the public and political perception has been that the additive doesn't work". The feeling at ICI is that it might take a real plane crash to put the impetus back into the development of safer fuels. **Michael Cross**

## Myth of the Soviet shuttle

Piet Smolders and Michael Cross

**R**UMOURS that the Soviet Union is about to develop its own reusable space shuttle may be premature. Aleksandr Serebrov, a cosmonaut who has flown on the Salyut space station, has told *New Scientist* that the Soviet Union will continue to use small, tried-and-tested Soyuz capsules to transport cosmonauts and materials to the orbiting Salyut space station.

"Why would you drive a big American car when a 2CV would do just as well," Serebrov said. "With the present frequency of shuttle flights, a space-aircraft is an extremely expensive means of transport. Only if you launch a fully loaded space shuttle every week would it become profitable."

Rumours about a Soviet shuttle programme began with reports in the American magazine *Aviation Week and Space Technology*. For example, a recent issue contained a photograph of a Soviet bomber, the Myasitsyev Mja-4, carrying on its back a craft that looked suspiciously like an American space shuttle.

The Russians carried out gliding and landing tests with the model, similar to those the Americans carried out in 1977 by releasing the shuttle Enterprise from a Boeing 747.

The Soviet bomber, code-named Bison by Nato, made test flights with its load from Ramskoye air base, east of Moscow.

Serebrov admits that the Soviet Union has carried out tests with a small shuttle model less than 4 metres long and weighing just one tonne. For these flights, a conventional rocket took the model into orbit.

After one rotation, the model reentered the atmosphere. On one test, the model landed in the Indian Ocean, in two others it landed in the Black Sea. An Orion aircraft from the Australian marines photographed



*This is Soviet shuttle technology as photographed by Australian Marines; but there is no programme, says Serebrov*

the landing in the Indian Ocean, three years ago.

It is clear that the Soviet Union is interested in the technology of reusable spacecraft, which it calls the VKK (Vozdushno-Kosmicheski Korably air-space ship). Like the Americans, the Russians want to understand the technology. But, according to Soviet engineers, they have no rival to the American shuttle and have no current intention to develop one.

If *Aviation Week*, the house organ of



P.L. Smolders

America's aerospace industry, is exaggerating a Soviet threat to the US, it would not be the first time. For example, it claimed that the spacecraft Kosmos-1443, which was coupled to the space station Salyut 6, was loaded with small rockets that could be used against other spacecraft.

But General Vladimir Shatalov, head of the cosmonaut team, denied this. Shortly afterwards, in 1982, the Russians released photographs which showed the craft to be what the USSR had always claimed: a module designed to enlarge living space aboard the Salyut by about half.

Cosmonaut Serebrov's statements about a space shuttle make a lot of sense. The Russians emphasise their goal of building a large permanent space station, as a successor to the present Salyut

7. In such a station, lunar modules could be assembled, released, and taken in again for repair.

The US's shuttle may itself soon look like an expensive folly when the American space station is flying—by 1992, if all goes well—it will take over many of the tasks carried out during shuttle missions. The shuttle will serve simply as a means of transport to and from the space station, a job that can be

done quite easily with ordinary rockets.

Will the Soviet Union stay out of the shuttle race for good? Serebrov says: "For the time being, we don't need it. But if the Americans continue to utilise the military possibilities of the shuttle, in the long term we could also be forced to develop a space-aircraft." □

## Microwaves linked to cancer in Polish study

**A** POLISH study has found that soldiers who are regularly exposed to heavy doses of microwaves contract cancer at three times the rate of other soldiers. Scientists at the Centre for Radiobiology and Radioprotection in Warsaw say they have found "a definite increased risk of neoplasms resulting from occupational exposure" to microwaves.

The possible long-term health effects of microwave exposure have been debated for several years and a handful of other studies have pointed to a possible link with cancer. The Polish results are reported in the March issue of the New York-based newsletter *Microwave News*. They come from an analysis of data on career soldiers from 1971 to 1980.

Although only three per cent of the Polish soldiers received heavy doses of microwaves, that group suffered 8.8 per cent of the cancers found among the soldiers in the study.

Exposed soldiers were 6.7 times more likely to contract cancer of the lymphatic

system and the blood-forming organs, and 4.3 times more likely to suffer thyroid cancer. The rate of lung cancer, the commonest type of cancer among Polish soldiers, was virtually the same regardless of the extent of exposure.

The increase in cancer rates varied with age. Soldiers in their 20s who received high doses of microwaves were 5.5 times more likely to get cancer than their compatriots of the same age. Those in their 50s were only 1.6 times more at risk.

This variation could reflect factors such as the reduction in the activity of the endocrine glands. The number of soldiers involved was not indicated in the paper, but *Microwave News* said the study was "by far the largest on the effects of non-ionising radiation".

The Polish results support the evidence of an animal study by Arthur W. Guy at the University of Washington in Seattle, sponsored by the US Air Force. He looked at a broad range of effects in rats exposed to pulses of microwave.

He found that rats exposed to microwaves contracted tumours 3.6 times as often as those in a control group. Half the cancers found in his study were endocrine tumours.

An earlier Polish study published in 1982 had reported that microwaves tended to accelerate the development of tumours in mice.

The degree of the Polish soldiers' exposure to microwaves was not specified in the report. But Louis Slesin, the editor of *Microwave News*, says the results "make further research imperative, given the large number of Americans exposed to microwaves on the job and in the military".

However, the US government does not seem interested. The air force has no plans to follow up on Guy's work and Slesin says that the Reagan administration's budget proposals for 1986 will severely reduce research on non-ionising radiation, including microwave, radiowave and electric fieldwaves for power lines.

Jeff Hecht, Boston

## Nuclear inspectors threaten to leave en masse

Roger Milne

BRITAIN'S nuclear inspectors are in turmoil. More than half of them have threatened to leave their work with the Nuclear Installations Inspectorate (NII) because they do not want to obey a government edict and move to Bootle on Merseyside. Fifty of them, more than half of the inspectorate's staff of engineers and scientists, have made their dissatisfaction public by advertising in the national press their willingness to take other jobs.

Their advertisement was placed in a national newspaper under the heading "Nuclear Safety Engineers Seek Employment". It has already attracted offers from firms in the nuclear business, such as Rolls-Royce, which builds the pressurised-water reactors that power Britain's nuclear submarines.

A spokesman for the Health and Safety Executive, the parent body of the NII, said this week that if the threatened exodus of staff happens, safety work at Britain's power stations will inevitably be held up. "But we are not going to compromise on nuclear safety," he said.

The inspectorate has not yet recovered from the demands of appearing over two years at the Sizewell-B public inquiry. It faces another heavy drain on resources as the long-term safety review of Britain's

ageing Magnox reactors gathers pace.

There are continuing problems with Britain's oldest Magnox reactor, run by the Central Electricity Generating Board at Berkeley in Gloucestershire. Arguments about the replacement of cracked gas bellows at the plant have been going on for several years.

The planned move to Merseyside will coincide with the NII's consideration of the safety assessments for Britain's most modern advanced gas-cooled reactors at Heysham and Torness. Inspectors do not expect to have the time or the resources to check the safety cases in as much depth as they would like. They say that it will probably only be possible to double-check a third of the detailed work which is being submitted by the generating board and the South of Scotland Electricity Board, together with the National Nuclear Corporation. The Institution of Professional Civil Servants, which represents most of the nuclear inspectors, has written to all MPs voicing its concern that the plans for dispersal are affecting morale and jeopardising safety standards (*New Scientist*, 24 January, p 3).

One trend which is worrying the union is

the dramatic decline in site visits by inspectors. From a peak of 762 visits to all nuclear sites in 1981, the tally dipped to 400 during 1983-84. The institution warns that this drop in visits could have "potentially serious consequences for reactor safety at operational nuclear power stations". Because of their current workload, inspectors have been forced to consign to the back-burner such matters as inspection at sites run by the Ministry of Defence and the UK Atomic Energy Authority. Studies into safety at fast reactors and work on siting policies for nuclear chemical plants have also suffered.

Peter Bottomley, an employment minister who oversees the NII, recently reiterated his commitment to the relocation of most of the NII to Merseyside. He stressed that "standards will be maintained". □

## El condors passé



J. C. Romanay/Nat. Audubon Society

## Return of the big, bad wolf

FEARS that the Scandinavian wolf may be on the verge of extinction have been confounded. Supporters of the wolf believe that two sets of wolf pups may be born in southern Sweden this summer.

Their confidence follows the discovery of spots of blood in snow in the woods of Warmland County, near the border with Norway. Scientists deduce that two adult female wolves have come into season during the last month.

The wolves are members of a pack of five which, for nearly a year, has kept to a territory within 25 kilometres of the village of Bjurberget. Scientists who have been following the wolves since they first bred in the area in 1983 (*New Scientist*, 9 November 1984, p 28) believe the pack consists of the original pair, one of the pups born in 1983 (which is breeding for the first time this season), and two pups born last summer. The females could both give birth next month.

Only one other wolf is known to exist in Sweden south of the Arctic Circle. This is a female, again assumed to be one of the 1983 pups, that scientists have located about 400 kilometres north of Bjurberget near Östersund. She too is on heat. But, as her season only lasts three weeks and she is not with a pack, scientists

will be surprised if she finds a mate. It seems likely that the other four pups born in 1983 have all been killed.

The survival of Scandinavian wolves is a matter of great controversy. Farmers are demanding compensation for livestock lost to marauding wolves, and some parents are demanding special protection for children on their way to school in remote rural areas.

On 16 March, nearly 500 people set out on skis to look for wolf tracks along the border between southern Norway and Sweden. In Sweden, no wolves were found outside the Bjurberget territory. In Norway, along 2200 kilometres of the border, no sign of any wolves was found. Between Tørbet and Trysil in Hedmark, where last year farmers received subsidies for the loss of sheep, the searchers found a number of straying farm dogs.

Tor Kvam, a spokesman for the Norwegian Directorate for Wildlife and Freshwater Fish, confirmed last week that there have been no reliable reports of wolves from the whole of the southern half of Norway this year. There are only two possible sightings, both far to the north, one near Brønnøysund, on the coast, and the other in Liene. □



R. E. Chappin/NP

Blood in the snow brings hope

THE POPULATION of California condors in the wild could have fallen as low as 11. Four birds, including three from breeding pairs, have gone missing over the last six weeks. The break up of the breeding pairs was described last week as a devastating blow to attempts by scientists to save the huge bird from extinction. Last year five breeding pairs were identified.

The falling population has also led to the postponement of plans to release three one-year-old female condors that have been bred in captivity from eggs taken from nests last year. They were to have been released into the wild in May.

The Los Angeles Zoo and the San Diego Wild Animal Park are rearing 16 birds, including 15 juveniles. Scientists want to release females from the captive flock into the wild to increase the genetic diversity of the breeding pairs. But this plan will have to be reassessed.

The captive breeding programme itself is now also in peril. Scientists from the Condor Research Center in Ventura hoped to obtain 13 eggs this year. By last week they had only two.

But scientists are not completely despondent. "Any wild population is going to have good years and bad years," says J. Michael Scott, director of the research centre. The catastrophic losses are all the more reason to manage the species, he says.

The condor, a vulture with a wing span of nearly 3 metres, is found in Californian forests inland from Santa Barbara. □



## Second virus linked to AIDS cancer

Omar Sattaur and Terry Hamblin

of AIDS (acquired immune-deficiency syndrome), may be caused by an as yet unidentified virus.

Kaposi's sarcoma (KS) has baffled scientists since it was first diagnosed. Prior to AIDS this cancer was confined to a region of central Africa. It was also seen among people whose immune systems were suppressed for medical reasons—for example to prevent a transplanted kidney being rejected. In both cases the disease was indolent and would often regress when the immune system recovered.

But KS in AIDS patients is different; it is far more aggressive, invasive and life-threatening. There is also a similar, more virulent KS on the increase in central Africa, and this "atypical" form is often unrelated to AIDS. Scientists have looked to the virus that causes AIDS as the possible culprit for KS—it does, after all, cause immunosuppression.

But more and more this idea is being dispelled by serological studies. These entail hunting for the AIDS virus in the blood. Scientists have found, for example, that people with "classical" KS in central Africa do not carry the AIDS virus, whereas those with the newer "atypical" KS do. Could the new form represent a mutated AIDS virus?

Professor Jan Desmyter, head of microbiology at the Catholic University of Louvain, in Belgium, last week told a meeting at the London School of Hygiene and Tropical Medicine why he thought this was unlikely. Desmyter mentioned two studies: one showing that 35 per cent of blood samples taken in 1970 from healthy mothers in Kinshasa in Zaire showed some reactivity with the AIDS virus, indicating that they have antibodies to the virus and so must have been in contact with it in the past. Because KS is increasing one would expect more reactivity in samples taken more recently, but the reverse is true.

In the second study, only 10 per cent of blood samples taken in 1980, from healthy Kinshasa mothers contained antibodies to the AIDS virus.

There are other reasons to suspect a novel virus in KS. The first is that haemophiliacs who develop AIDS through infected blood rarely develop KS even when they do develop the other symptoms of AIDS. Secondly, KS in AIDS was rare at the early stages of the disease but is increasing all the time.

New evidence from Denmark may dispel the idea that AIDS in the West will eventually affect men and women equally, as it now does in central Africa. Dr Mads Melbye and others from the Cancer Research Institute at Aarhus investigated the families of 14 haemophiliacs who had

all been infected by the AIDS virus from American clotting concentrate. Only one of the 35 individuals they examined had caught the virus from one of the haemophiliacs, and she was the only female sexual partner who practised anal intercourse.

Eight other wives or consorts, who all practised both oral and vaginal intercourse, were unaffected. It seems, therefore, that rupture of the very thin lining of the rectum is the route by which the virus is spread.

Does this mean that everyone with AIDS in central Africa is a sodomite? Almost certainly not. The betting among some scientists is on a blood-sucking insect vector for the disease. □

## Britain takes the road to ruin

BRITAIN'S main roads are starting to fall apart, according to an official survey. This is a result in part of cuts in spending on road maintenance and in part due to the increased pounding that roads are receiving from heavy lorries.

The National Road Maintenance Condition Survey, which is a rare product of cooperation between the government and local authorities, found that Britain's roads were 10 per cent worse than they had been in 1980, according to an agreed index of defects. Trunk roads, the highways which are maintained by the government, had deteriorated the least, and were only 8 per cent worse than in 1980.

But the local authorities' main roads were 25 per cent worse in urban areas, and 16 per cent worse in rural areas. Council spending on these roads has dropped by nearly 7 per cent over the period.

The report of the survey says that the deterioration of the local authorities' roads between 1980 and 1982 had been halted in 1983, but had resumed in 1984. Publication of the report was held up by the Department of Transport for several weeks because of the survey's embarrassing conclusions. The department has said for several years that the deterioration of roads shown in the survey have not been significant. □



## Signals unclear from satellite broadcasting

BRITAIN'S plans for satellite broadcasting are caught in a double bind. The Group of 21, a consortium made up of the BBC, the Independent Broadcasting Authority and electronics companies such as Thorn-EMI, seems undecided about which way to go.

There are two possibilities: ● The consortium could go forward with plans to have a service beamed into homes by 1989. To do this it must immediately promise the builders of the satellite that it will pay out £80 million per year for the hardware. But there is a risk that, by the time the service is in business, it could be undercut by a new generation of receivers that will take pictures from lower-powered

cheaper transmitters.

● The consortium could wait for the new technology before going ahead. But by then the country might be hooked on cable TV and have little interest in satellite broadcasting.

A major uncertainty is how well the 240-watt transmitters planned for the system will work. Existing telecommunications satellites use far fewer watts. The Japanese direct-broadcasting satellite, which was launched last year, uses 100 watts for instance. However, it has turned out to be a failure because two of its three transmitter tubes stopped working soon after launch.

The British 240-watt tubes have yet to be

tested in space. There is concern that they may not be able to stand the regular switching on and off, which will occur 88 times a year, whenever the solar panels that will power them pass into eclipses.

The group calculates that to provide a three-channel service with a 95 per cent certainty of providing programmes for 10 years, three satellites will be necessary, costing £86 million per year. Two would be in orbit and one spare on the ground. If the consortium would accept a probability of 75 per cent, it could get away with two satellites. This would halve the cost of the venture. With risks and costs as high as this, the scope for dithering is immense.

Barry Fox

ANDERSON &amp; LEWINE, LONDON

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# Britain may have *Bigeye* nerve gas by 1989

Now that cruise missiles are safely in place, Britain may take the US's chemical weapons as well. Officials have just told the US that they back Reagan's plans to make more nerve gas

Judith Perera

**T**HE BRITISH government denies that it has any intentions of manufacturing its own chemical weapons. Yet Britain may soon become a repository for a new generation of binary chemical weapons—nerve gases that will be manufactured in the US and stored at American bases in Britain. The British government is now discreetly encouraging the US Congress to vote money for the weapons' manufacture.

The Reagan Administration has asked Congress for a total of \$1.4 billion to spend on chemical weapons. This includes \$207 million for the production of shells and bombs containing binary nerve gas. Last May, the House of Representatives rejected by 247 votes to 179 a similar request for funding; the request was not even put before the Senate.

After the defeat, the Administration appointed a bipartisan "blue-ribbon" commission of nine prominent individuals to consider the issue and report to Congress. The commission visited London on 29 March and, at a brief lunchtime meeting, British officials told the commission that they believed the modernisation of US chemical weapons was desirable. It would help to convince the USSR of the need for total chemical disarmament.

The commission is expected to submit its report to Congress on 15 April, just one week before the Armed Services Committees of both houses begin to consider their budgets. The commission will base its report on evidence collected in Washington, Bonn, Brussels, Paris and London. The veiled green light given by Britain is expected to be decisive, not only for the commission but also for Congress.

London's support is not the only reason why the commission is expected to come down in favour of binaries. The commissioners are already late in submitting their report, so to meet the 15 April deadline they will have to depend heavily on their staff, all of whom were drawn from the Pentagon.

Moreover, the commissioners themselves have probably been in favour of



*Will Haig and Brzezinski give the US Army the go-ahead to start unpacking canisters of binary nerve gas at Greenham?*

chemical weapons from the start. One Congressional source described its composition as "outrageous". Two members of the commission, Barber Conable and John Erlenborn, are former congressmen: both voted for binaries in the past. The former US Secretary of State and Supreme Commander of NATO, Alexander Haig, is also a member: in 1978 he noted that the US was "very weak" in chemical weapons and that "sometime in the near future this will have to be reassessed". President Carter's National Security Adviser, Zbigniew Brzezinski, is also on the panel and is also known to favour chemical weapons.

Only three of the commissioners would seem to have no preconceived ideas about binaries: retired Army General Richard Cavazos; Phillip John Bakes, the President of Continental Airlines, and a former Deputy Defense Secretary, John Gordon Kester. The chairman of the commission is a former Ambassador to West Germany and the USSR, Walter Stoessel. Perhaps most significant is the choice of Thomas J. Welch as the commission's Executive Secretary. Welch was recently appointed Deputy Assistant for Chemical Matters to the Secretary of Defense, leaving his post as Deputy Director for Doctrine at the US Army Chemical School. Before that he was an Associate Technical Director at Fort Detrick, the

main US chemical weapons research establishment.

In the past, the hostility of European governments to chemical rearmament has swayed congressional votes, more especially because binaries were originally conceived with the intention of being deployed in Western Europe. In the early 1970s, they were seen as a way of answering criticism about the dangers of existing stockpiles in West Germany. Nerve gas Stocks there were estimated at about 1000 tonnes. Among the advantages of binaries listed by US Army researchers at the Edgewood Arsenal, New Jersey, were that they were "OCONUS (Outside Continental United States) Pre-position Acceptable".

The army was particularly peeved, therefore, when in 1974, Congress refused funds for initial development, mainly on the grounds that Europe did not want them. At that stage, efforts were concentrated on artillery shells for deployment in West Germany, but priorities have changed over the years. It has become clear that the West German government would resist any attempt to modernise or increase stocks on its soil. Now, in addition to the shells, the US has accelerated development of the *Bigeye* bomb, generally seen as intended for deployment in Britain.

Anglo-American talks on chemical rearmament were held at various levels in 1980. The then US Secretary of Defense,

## The 25-year countdown to Bigeye

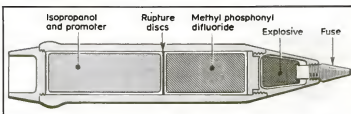
**B**INARY chemical weapons are designed to be safer than their predecessors because their chemical fillings are separated into two less toxic components. These mix together, inside the munition, en route to the target. The components can be stored separately, and loaded just before use.

US research on binary weapons began in the 1950s, partly because the US Navy felt uneasy about the safety of storing chemical weapons onboard ship. In 1965, the Navy began its own binary programme to develop a bomb—the 500-lb *Bigeye* which contains VX nerve gas in binary form. During the 1960s, the Vietnam war and a series of accidents made chemical weapons increasingly unpopular. In one incident, 6000 sheep died from exposure to nerve gas near the Dugway testing ground in Utah.

In 1969, President Nixon announced that the US would cease production of chemical and biological weapons, and work on *Bigeye* stopped. The period of detente between the superpowers led, in 1972, to a treaty banning the production and stockpiling of biological weapons. Bilateral talks on chemical warfare began in 1974 in parallel with the more general chemical disarmament talks in Geneva. In 1975, the US finally signed the 1925 Geneva Protocol banning the use of chemical and biological weapons.

In this atmosphere, the US Army Chemical Corps began pushing the binary programme as a way of making chemical weapons "safe" and acceptable. The Army drew up plans in 1973 for the procurement of binary artillery shells, and the *Bigeye* programme was restarted as a joint Army-Navy venture. But Congress refused to allocate the money.

By the late 1970s, however, attitudes had changed. Memories of Vietnam had faded and the Soviet Union's invasion of Afghanistan encouraged a new "cold



The 155-mm shell for binary nerve gas



Will US chemical weapon stores dot the English landscape?

war" atmosphere. In 1980, the newly elected President, Ronald Reagan, made known his commitment to chemical rearmament. Bilateral talks with the USSR were suspended amid reports (still unconfirmed) that chemical weapons supplied by the Soviet Union had been used in Afghanistan and Southeast Asia.

Congress voted money to build a plant at Pine Bluff Arsenal to produce the filling for binary munitions. But while Congress has continued to vote funds to complete Pine Bluff, it has balked at allocating funds for weapons procurement. This would, it felt, signal a new chemical arms race. For the past three years, Congress has refused Reagan's requests for money to begin full-scale production of binaries.

The weapons in question are 500 000

rounds of 155-millimetre howitzer shells (M687) filled with binary sarin nerve gas (GB2) and 40 000 500-lb *Bigeye* bombs (VX2 Spray-bomb BLU-80/B). Components for GB2 are two liquids: 98 per cent methylphosphonyl difluoride (DF) mixed with 2 per cent NN'-diisopropylcarbodiimide as a stabiliser; and 72 per cent isopropyl alcohol mixed with 28 per cent isopropylamine (KZ) as a reaction promoter. Both are relatively stable in storage.

For *Bigeye*, the components are a liquid and a solid: Ethyl 2 diisopropylaminoethyl methylphosphonate (QL) mixed with the same stabiliser; and powdered rhombic sulphur (NE). These components are less stable in storage and *Bigeye* has had some technical problems as a result. Other binary weapons are being developed. A new, still-secret class of nerve gas was discovered in 1971—an "intermediate volatility agent" which will eventually replace both VX and GB. The components of these binary weapons, which are less toxic than the original nerve gas are by no means harmless. DF, for instance, are as poisonous as strychnine. But the proponents of binaries no longer depend simply on the safety arguments. Now they stress the need to modernise and increase US stocks to maintain parity with the USSR as a deterrent. □

Harold Brown, publicly suggested in June of that year that Britain should acquire chemical weapons. Prime Minister Margaret

Thatcher denied that Britain had any plans to do so, although she expressed her concern about the Soviet chemical threat.

Over the past few years, British efforts have been concentrated on the disarmament talks in Geneva. This is a genuine strand in Britain's foreign policy. But in the absence of a treaty banning chemical weapons completely, Britain has long been committed to hosting binary nerve gas munitions once they are in production.

This British commitment has been deliberately played down during the controversy over the deployment of cruise missiles.

Now that cruise is safely installed at

Greenham Common, it seems that the British authorities have decided that they can take on the binaries issue. This is the message that the Presidential commission has taken back to Washington.

If Congress votes to release the money, *Bigeye* bombs will start rolling off the production lines in 1989. The most likely locations for their deployment would be the USAF bases at Lakenheath and Upper Heyford, where F-111 bombers are stationed. Last year, Congress voted \$2.4 million for the construction of 10 "munitions storage" igloos at Lakenheath. Initially, however, the chemicals would probably be brought into the main USAF storage depot at RAF Welford. In times of emergency they would be brought up to "intermediate resupply points" within 20 miles of the bases. In the longer term, the US is developing chemical warheads for cruise missiles; and these would be deployed at Greenham and Molesworth. The US's soldiers at Greenham are already being trained to cope with chemical as well as nuclear accidents. Nuclear, chemical and biological defence equipment and shelters are already in place. □



The US is already developing chemical warheads for missiles

# Chemistry between the stars

Radio astronomers have revealed that the space between the stars forms a vast laboratory where chemical reactions previously unknown on Earth take place. But these reactions can be explained in terms of the extreme conditions: the laws of chemistry as we know them are true throughout the Galaxy

Tom Millar and David Williams

THE EMPTY space between the stars is a very good vacuum, by laboratory standards, but it is far from being devoid of matter. Astronomers have known for decades that interstellar space contains small particles of dust and also tenuous gas, mainly in the form of hydrogen atoms. However, few researchers believed that molecules could exist in interstellar space, because it seemed that ultra-violet radiation from hot stars would break the chemical bonds and dissociate them into atoms.

In the past 15 years, radio astronomers have therefore caused something of a revolution in astronomy by discovering molecules in space—not just a few kinds, but an amazing variety. The total now stands at something like 60 different molecules (Table 1). They range from the simplest and most familiar molecules, such as molecular hydrogen ( $H_2$ ) and carbon monoxide ( $CO$ ), to large and exotic species such as  $HC_{11}N$ , not previously known in the laboratory.

These molecules must be formed by chemical reactions in space. Their detection has raised many fascinating problems both for chemistry and for astronomy. Chemists may now regard interstellar space as a vast natural laboratory, in which they can examine the results of chemical reactions occurring at densities and temperatures that they usually cannot attain in the laboratory on Earth. Because these conditions are so different from those that

chemists normally deal with, it is not surprising that some of the molecular radicals (for example,  $OH$  or  $CH$ ) have only a fleeting existence at atmospheric temperature and density. In interstellar space where densities are very low, different kinds of chemical reaction tend to predominate, and substantial

populations of these relatively unfamiliar species can build up. In principle, the molecules in space can tell the chemist a great deal about various types of reaction that occur in these unusual conditions.

For the astronomer, the radio emissions from these molecules can reveal the physical conditions of their environment. They show that the interstellar medium is an exciting, dynamic place, a reservoir from which stars are formed, and to which the stars eventually return their "ashes" of nuclear burning. Recent observations of the molecules' radio emissions are helping astronomers to study the intimate details of how stars form (*New Scientist*, 1 March 1984, p 12). This information comes from the relative strengths of radio emission at the various wavelengths (spectral lines) that a particular molecule can emit.

The spectral lines from most molecules are produced by the molecule changing the rate at which it is spinning round. The molecules are set spinning by collisions with molecules of hydrogen, the most abundant species. A comparison of the strengths of the spectral lines can therefore reveal how



Dark clouds in Monoceros are a cosmic test tube

Mount Wilson/Palomar Observatories

Table 1: The molecules in space

| Number of atoms: |                               |                   |                       |                     |                                 |                                  |                                    |                   |                       |  |  |  |  |  |  |
|------------------|-------------------------------|-------------------|-----------------------|---------------------|---------------------------------|----------------------------------|------------------------------------|-------------------|-----------------------|--|--|--|--|--|--|
| 2                | 3                             | 4                 | 5                     | 6                   | 7                               | 8                                | 9                                  | 11                | 13                    |  |  |  |  |  |  |
| H <sub>2</sub>   | N <sub>2</sub> H <sup>+</sup> | NH <sub>3</sub>   | C <sub>4</sub> H      | CH <sub>3</sub> OH  | CH <sub>3</sub> CCH             | CH <sub>3</sub> COOH             | CH <sub>3</sub> OCH <sub>3</sub>   | HC <sub>9</sub> N | HC <sub>11</sub> N(?) |  |  |  |  |  |  |
| CO               | HCO <sup>+</sup>              | H <sub>2</sub> CO | CH <sub>3</sub> NH    | CH <sub>3</sub> SH  | CH <sub>3</sub> CHO             | CH <sub>3</sub> C <sub>2</sub> N | CH <sub>3</sub> CH <sub>2</sub> OH |                   |                       |  |  |  |  |  |  |
| CH               | HCS <sup>+</sup>              | H <sub>2</sub> CS | NH <sub>2</sub> CN    | CH <sub>3</sub> CN  | CH <sub>3</sub> NH <sub>2</sub> |                                  | CH <sub>3</sub> CH <sub>2</sub> CN |                   |                       |  |  |  |  |  |  |
| CN               | HCN                           | HNCO              | HCOOH                 | NH <sub>2</sub> CHO | CH <sub>3</sub> CHCN            |                                  | CH <sub>3</sub> C <sub>2</sub> H   |                   |                       |  |  |  |  |  |  |
| CS               | HNC                           | HNCS              | CH <sub>3</sub> CO(?) | HC <sub>3</sub> N   | HC <sub>3</sub> N               |                                  | HC <sub>3</sub> N                  |                   |                       |  |  |  |  |  |  |
| C <sub>2</sub>   | C <sub>2</sub> H              | C <sub>2</sub> H  |                       |                     |                                 |                                  |                                    |                   |                       |  |  |  |  |  |  |
| CH <sup>+</sup>  | H <sub>2</sub> O              | C <sub>2</sub> O  |                       |                     |                                 |                                  |                                    |                   |                       |  |  |  |  |  |  |
| OH               | SO <sub>2</sub>               | C <sub>2</sub> N  |                       |                     |                                 |                                  |                                    |                   |                       |  |  |  |  |  |  |
| NO               | H <sub>2</sub> S              | HOCO <sup>+</sup> |                       |                     |                                 |                                  |                                    |                   |                       |  |  |  |  |  |  |
| NS               | HCO                           |                   |                       |                     |                                 |                                  |                                    |                   |                       |  |  |  |  |  |  |
| SO               | OCS                           |                   |                       |                     |                                 |                                  |                                    |                   |                       |  |  |  |  |  |  |
| SiO              | HNO(?)                        |                   |                       |                     |                                 |                                  |                                    |                   |                       |  |  |  |  |  |  |
| SiS              | HOC <sup>+</sup> (?)          |                   |                       |                     |                                 |                                  |                                    |                   |                       |  |  |  |  |  |  |

This list includes all the molecules that are currently known in interstellar space, but it does not contain some molecules (for example  $SiCC$ ) that are found only in dust shells ejected from stars, nor molecules that differ by containing a different isotope (such as deuterium for hydrogen)

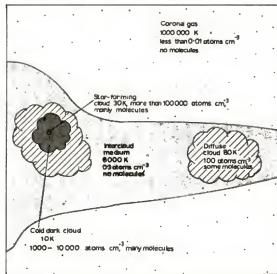


Figure 1 Gas occurs in a wide range of conditions

frequently and how forcibly the molecules are being hit by hydrogen molecules, and hence can provide information on the density and temperature in a particular region of the interstellar gas. Carbon monoxide turns out to be especially useful for this purpose. By this means, astronomers have discovered the typical conditions in various regions in interstellar space (Figure 1).

But the radio spectra potentially hold much more information. If we can understand the underlying chemistry which gives rise to the observed molecules, we can ascertain in great detail the conditions in these regions of space. This detail includes, for example, the relative abundances of different elements there, the intensity of ultraviolet and other radiations in the region, and the flux of high-speed charged particles (cosmic rays). We should also be able to predict what other molecules, as yet unobserved, we might detect. To achieve all this we require a mathematical model of considerable complexity, and also a massive amount of chemical data. Experimental and theoretical chemists have risen splendidly to this challenge, and much new chemistry has emerged as a result of the astronomical stimulus. Interstellar chemistry has attracted a lot of interest and has become a rapidly developing, exciting branch of astronomy.

There are two problems in forming and maintaining the observed abundance of molecules in the low densities of interstellar space. First, the interstellar medium is bathed in starlight, especially from bright stars that emit most of their energy at ultraviolet and visible wavelengths. This radiation is sufficiently intense and energetic to break most of the molecules down to atoms in about 1000 years, a relatively short time in astronomical terms. Secondly, because collisions between atoms and molecules must be infrequent in these low-density regions, they must react two at a time. The efficient three-body reactions which dominate our earthly existence can play no

part in interstellar chemistry.

Fortunately, nature finds a way round these problems. The grains of interstellar dust provide shielding against the radiation. These small particles are mixed with the gas throughout the interstellar medium, and in the denser gas clouds the dust is correspondingly more concentrated. In a typical cloud, detected by the radio emission from carbon monoxide, the intensity of ultraviolet and visible light is reduced to less than 1 per cent of its intensity in normal interstellar space. What these grains are made of does not concern us here; their nature is still controversial (*New Scientist*, 28 February 1982). All we need to know is how strongly they extinguish starlight, and astronomers can determine that from observations.

The next problem is to find reaction routes that are suitably efficient. In our mathematical model, we must plan a series of reactions, starting with the elements that we know to be most abundant in the interstellar medium (Figure 2). This series of reactions must ultimately provide the observed molecules. Unfortunately, the simplest reaction between two atoms

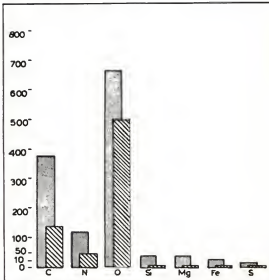
A and B

$A + B \rightarrow AB$   
is usually followed at once by  
 $AB \rightarrow A + B$

In other words, the atoms A and B usually bounce apart. We need more complicated types of reaction, usually involving ionised atoms or molecules.



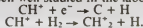
The radio telescope (above) at Kitt Peak, shows (Figure 2 right) that the proportions of elements relative to hydrogen is less in space (hatched) than it is in the Sun (grey)—the residue is in solid grains. Hot stars (below left) destroy molecules



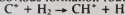
## 1: Shocking conditions in interstellar space

A PRIME example of failure in simple models of interstellar chemistry is the molecule  $CH^+$ . Optical astronomers discovered this molecule in the diffuse interstellar gas back in 1941 by its absorption of light from distant stars, but its origin is still far from clear. Our chemical model fails by a factor of 100 to account for the high abundance of  $CH^+$  observed towards a number of stars. Factors of 3, or even 10, we might swallow, but factors of 100 give severe indigestion.

The main problem with  $CH^+$  is that it is destroyed rapidly by two reactions that have been well studied in the laboratory:



The obvious formation route:



is very slow at the low temperature of interstellar clouds. But, if the temperature could

be raised to around 2000K, this formation reaction would be fast and would lead to substantial amounts of  $CH^+$ .

This kind of argument led Bill Watson and Moshe Elitzur, in Illinois, to suggest that shock waves in the interstellar gas could have a significant effect; they could perhaps raise the temperature of the gas sufficiently to drive this reaction. Shocks occur wherever there are supersonic motions in a gas, and the interstellar gas is stirred by many kinds of violent events, such as the explosion of supernovae and fast "winds" from young stars.

Other evidence has since supported the idea of interstellar shocks, especially infrared observations of regions where the hydrogen molecules are vibrating. The chemistry is thus telling us that the interstellar medium is a very turbulent place. □



Royal Observatory, Edinburgh

To work out the molecules we expect to find in an interstellar cloud, we can start by writing down a list of the important chemical reactions that we think are occurring in a particular type of cloud, with the rates at which the reactions proceed. Any particular molecule is formed in a number of ways: for example, the hydroxyl radical (OH) is formed by



(where  $e^-$  is an electron, and  $h\nu$  represents radiation). Molecules are destroyed in a variety of ways, too. For hydroxyl, we have



If we know the rate coefficients of all the reactions, and the abundance of all the species at a particular time, then we can write down the total formation rate of hydroxyl and the total destruction rate of hydroxyl at that time. It is not difficult, then, to find the abundance of hydroxyl at a later time. We can do this for all the species involved, starting with the initial values of all the atomic and molecular abundances that we expect to find, when it forms from tenuous interstellar gas, in our cloud, and then calculating step by step how the abundances change with time.

Alternatively, we can look instead for the equilibrium solution, the mix of molecules we should find when the chemistry is in a steady state and the formation and destruction of all species are just in balance. This should give the same result as the first approach, when we allow the time for the reactions to increase indefinitely. Indeed, this is what we find. The equilibrium is easier to calculate and so we prefer to work out the abundances of molecules this way.

To perform a calculation like this, we must put in values for many of the factors that influence the reactions, including the intensity of the radiation that disrupts molecules, the flux of cosmic rays that ionise elements, the relative abundance of elements in the cloud and so on. We make educated guesses about these parameters, perform the calculations, see how the molecules we produce compare with the results of observations. Then we explore the way in which our results change as we alter the values of the parameters that we began with. In this way, we hope to get good agreement eventually with the observations (for reasonable values of the various parameters). These calculations can be quite complex. The largest has some two hundred molecules involved in about two thousand reactions, although we usually prefer to work with

## 2: How to build big molecules in space

SOME LARGE molecules are built up by a succession of reactions. For a start, anything that can react with  $\text{H}_2$  will do so, because of the preponderance of  $\text{H}_2$  in these clouds. This is a rapid reaction, but it does not apply to neutral molecules and radicals (unless they are heated by a shock wave), and only certain ions are able to react.

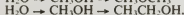
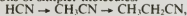
After this, we come to some slower processes. One of the most important is radiative association. Although we said that  $\text{A} + \text{B} \rightarrow \text{AB}$  is usually unimportant for atoms, it can be a fast process if A and B are molecules containing several atoms, because the energy of stabilisation is now shared between a number of chemical bonds. If one of A or B is an ion, so much the better, since longer range electrical forces increase the rate of collision. The process:



where R is a molecule containing several atoms (for example water,  $\text{H}_2\text{O}$ ) is so fast that it may occur on every collision. The new ion will probably react rapidly with an electron, and undergo dissociative recombination:



These two reactions thus form an efficient route for adding a methylene group ( $\text{CH}_2$ ) to the original molecule R. Such processes may lead, for example, to methyl and ethyl versions of simpler molecules:

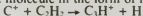


All these species have been observed and evidently arise from the HCN and  $\text{H}_2\text{O}$  formed in the simpler chemistry described earlier (Figure 3).

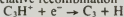
But not all the molecules in Table 1 fall into these categories. The most unusual sequence of molecules is that of the cyanopolyynes,  $\text{H}-(\text{C}\equiv\text{C})_n-\text{CN}$ , where  $n$  lies in the range 1 to 5. Many of these were identified by astronomers at Algonquin Radio Observatory, Canada, in association with the University of Sussex chemist Harry Kroto. Even more surprising is the trend in abundances in the polyynes.

Usually, heavier molecules are much scarcer than light ones, but here the abundances drop by a relatively small amount (about a factor of three) from one member of the sequence to the next. This indicates that there must be an efficient scheme for adding carbon atoms into hydrocarbons.

Chemists have studied carbon insertion reactions in the laboratory. We can, for example, add carbon efficiently to the acetylene molecule in the form of its ion:



What happens next is crucial. If the dissociative recombination



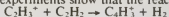
occurs, the sequence stops here, because carbon insertion doesn't work unless there is an H atom to spit out. However, if the

new, neutral hydrocarbon on which carbon insertion can occur



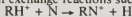
so forming a yet longer chain. We can see from this that conditions in the cloud control whether carbon chains keep growing, or stop at an early stage.

Reactions of other types (the so-called condensation reactions) can add whole groups to molecules. For example, laboratory experiments show that the reaction:



is fast. It adds two carbon atoms to the carbon chain.

Atom exchange reactions such as



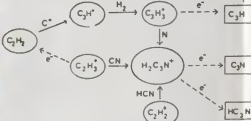
may occur readily enough to insert nitrogen or other atoms into a molecule. With reactions of these types, we can devise plausible routes to many of the larger molecules in Table 1. Unfortunately, there are no measured rates for many of these reactions, so there is a big uncertainty about the guesses we must make.

We can summarise the suggested routes for forming the small cyanopolyynes  $\text{HC}_3\text{N}$  in the following diagram, along with the related species  $\text{C}_3\text{H}$  and  $\text{C}_3\text{N}$  that are also found in interstellar clouds. Detailed modelling shows that the reaction between  $\text{C}_3\text{H}_3^+$  and N is the most important pathway to  $\text{H}_2\text{C}_3\text{N}^+$  and thence to  $\text{C}_3\text{N}$  and  $\text{HC}_3\text{N}$ . We can draw up similar routes for



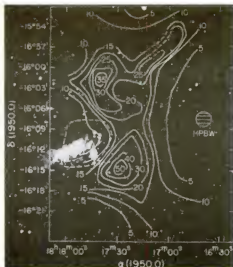
The 42-metre radio telescope at Algonquin, Canada, searches for cyanopolynes.

electron abundance is not too high, then  $\text{H}_2$  can associate with the  $\text{C}_3\text{H}^+$  to give  $\text{C}_3\text{H}_3^+$  before recombination. When this ion recombines, it gives  $\text{C}_3\text{H}$ , and we have a



This reaction network converts acetylene to  $\text{C}_3\text{H}$ ,  $\text{C}_3\text{N}$  and the cyanopoly-yne  $\text{HC}_3\text{N}$ .

the production of  $\text{HC}_3\text{N}$ , but the lack of any relevant laboratory data prevents us from making a useful comparison between theory and observation. □



Dense clouds about the Omega Nebula

### 3: Tracking down a molecule

THE CLOSE interaction between observers, theoreticians and experimentalists is nicely illustrated by the recent identification of a new interstellar molecule,  $C_3H$ . Radio astronomers at the Onsala Space Observatory in Sweden had found two new spectral lines in the expanding gas around the old star IRC+10216. Guided by quantum mechanical calculations by Sheldon Green in New York and David Cooper in Harvard, they tentatively identified the lines as coming from  $C_3H$ .

In a parallel development, Bohme in Toronto and Adams and Smith in Birmingham were performing laboratory experiments that indicated the radiative association reaction



was fast. In Manchester, our detailed chemical models showed that when this

reaction was followed by a dissociative recombination:



it could lead to the efficient formation of  $C_3H$  in the gases around IRC+10216. This gave chemical support to the tentative identification.

The model calculations also showed that similar chemistry should occur in Taurus Molecular Cloud 1, and that this should also show emission from  $C_3H$ . In June 1984, the Swedish astronomers detected several emission lines in the Taurus cloud which agreed with the  $C_3H$  lines in IRC+10216. This identification was finally made secure when Pat Thaddeus and his co-workers in New York were able to obtain the first microwave spectrum of  $C_3H$  in an experiment that they performed in the laboratory. □

simpler chemical networks. Because of this complexity, and because we must try many numerical experiments to fix the observations, such calculations are best performed on a large computer (Figure 3).

Once we have a good agreement between our computer results and the observations of a particular interstellar cloud, we can say we have a "chemical model" of the cloud. But we can never claim to have a *unique* solution to the state and composition of the cloud, partly because the abundance of molecules that we can derive from the observations is always rather uncertain, and partly because other combinations of

the simplest type of calculation (the equilibrium solution), and their results are in surprisingly good agreement with the observations. That is, for reasonable values of all the astrophysical parameters that we can choose (the radiation intensity, the cosmic ray flux, and so on) we can obtain abundances for almost all the molecules that are within a factor of five of the observed abundances. This may not seem like good agreement, perhaps, but it is the best that current models can achieve.

We call this agreement "surprisingly good". Why? The reason is that we know perfectly well that the model ignores a number of factors. The main problem is whether the cloud has time to reach a state of chemical equilibrium. A calculation that follows the changing abundances of molecules in this cloud shows that more than 30 million years must elapse for the chemistry to come into equilibrium (Figure 4a). There are good astronomical reasons for believing that something should have happened to the cloud during this period. This was ample time for it to collapse under its own weight, or, alternatively, to disperse and become a large diffuse cloud; to collide with another cloud, or suffer an impact from an interstellar shock. But it seems unlikely that it has sat quietly for 30 million years, in exactly the same *physical* state, waiting to come into chemical equilibrium.

This suggests that there are other processes going on. There is indeed one process which is often ignored, an yet which may be overwhelming in its importance. It concerns the grains.

When hydrogen atoms strike the surfaces of grains, they are converted to hydrogen molecules, which then evaporate back into the surrounding gas. But the grains are so cold that most other molecules condense on to them. In time, all the molecules must collide with a dust grain. The rate of accretion is surprisingly short. In the Taurus dark cloud, for example, we would expect half the gas to condense out after only 100 000 years. With a half-life this short, no molecules should be detected in such a cloud after, say, two or three million years (Figure 4b). Molecular abundances would then become excruciatingly sensitive to the age of the cloud. The fact that we *do* detect molecules in dense clouds therefore requires some explanation—and it is the basis of much discussion among interstellar chemists at the present time.

Some researchers argue that accretion does not work in this way, and that there are removal mechanisms helping to keep molecules off the grain surfaces and in the gas. Mayo Greenberg and his colleagues, in Leiden, have suggested that the

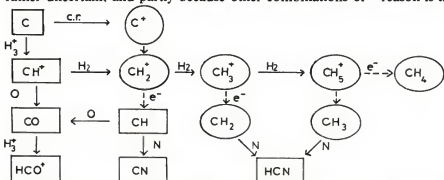


Figure 3 Carbon reacts by colliding with other molecules, cosmic rays (c.r.) and electrons. Rare species have been found in space; those circled are undetected

parameters in the model would give similar results. We can only claim to have a model that is consistent with the observations. Nevertheless, the technique is successful in producing a plausible description of interstellar clouds. The occasional lack of agreement can point us to unusual physical conditions in the gas (Box 1).

These chemical networks lead us only to the simpler interstellar molecules. What about the larger molecules found recently? Although our knowledge of these chemical pathways is less secure, recent work by Eric Herbst, in North Carolina, and by one of us (Tom Millar) has established some general paths, founded on the beautiful laboratory work of David Smith and Nigel Adams, in Birmingham, and Diethard Bohme, in Toronto (Box 2). The study of these clouds provides many examples of the fruitful interaction of the observers, the theoreticians and the laboratory workers (Box 3).

Taurus Molecular Cloud 1, for example, is a cold, dark, isolated, and quiescent dust cloud which contains a wide variety of molecules. To date, radio astronomers have detected some 28 different species in this cloud, and it is a good object for us to attempt to model mathematically. Tom Millar and Tony Freeman, in Manchester, have performed

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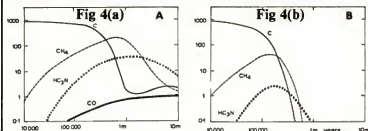


Figure 4 (a) Reactions change the amounts of atoms and molecules towards equilibrium (1); but (b) grains should mop them up

molecular mantle that begins to build up on a grain is energised by ultraviolet radiation and cosmic ray particles. The mantle therefore contains a population of reactive radicals. Eventually, an adjacent pair of radicals will recombine; the energy released heats up the whole mantle, so triggering off reactions between all the other radicals; and the ensuing microexplosion returns some of the mantle material to the gas. Walter Duley, in Toronto, has put forward an alternative idea. He argues that reactions at grain surfaces between pairs of atoms (or between atoms and molecules) release enough energy more or less continuously to keep the grains clear of absorbed molecules. Both these mechanisms are interesting, because they suggest that reactions at grain surfaces, in one form or another, play a crucial role inside dense interstellar clouds. Wilfrid Boland and Teije de Jong have put forward an alternative idea. They suggest that turbulence in the cloud may be continuously dredging up material from its dense interior, where the grains have accreted mantles. When these grains reach the edges of the clouds, they are exposed to radiation from stars beyond, which evaporates the mantles.

Another possibility, explored by Tom Hartquist, in Maryland, and one of us (David Williams), is that accretion does actually occur, and the grains do acquire an appreciable mantle over a period of a million years or so. Eventually, however, interstellar shock waves will disrupt the clouds and return the fragile mantle material to the gas, partly as molecules and partly as atoms. Obviously, this mechanism means that any cloud where we observe molecules must have been shocked (even lightly) in the last few million years. There is some evidence to support this viewpoint. Many cold clouds show evidence for surprisingly fast gas motions, which could be due to a shock, and also an unexpectedly high abundance of carbon atoms, which could have been shaken free from disrupted grain mantles.

It remains to be seen which of these pictures turns out to be correct; possibly, a combination will be required. But it is very exciting that grains—so long ignored in interstellar chemistry—now seem to play a major role, linking chemistry with the dynamics of the cloud and significantly modifying the cloud's evolution. For all the grains accomplish in the interstellar medium, however, they remain an enigma, and their role will not finally be clear until we fully understand their nature.

This linking is the latest example of the immensely beneficial interaction of chemistry and astronomy that has flourished in recent years. The astronomers' insatiable demand for chemical data has stimulated chemists to major new efforts. Indeed, in the short history of the subject of interstellar chemistry, the response of both laboratory and theoretical chemists to this stimulus has been remarkable. Chemistry has helped to show astronomers the wealth of information locked up in molecular observations, and has demonstrated the exciting range of conditions present in the interstellar medium. Finally, interstellar chemistry allows us to conclude that the laws of chemistry are the same all over the Galaxy, and are probably universal. □

Dr Tom Millar is a lecturer in the department of mathematics at the University of Manchester Institute of Science and Technology, where Dr David Williams is professor of theoretical astrophysics.

# Optical memories for home computers

Computing, sound and video all need cheap ways to store huge amounts of information. So far, each has used a different method. Now video and audio discs are being adopted as computer memories

Barry Fox

THE REVOLUTION in "information technology" follows from one simple fact. It is cheaper and faster to send data down a wire than it is to move people or pieces of paper round the world.

The *Economist* magazine prints simultaneously in Britain and the US. At first, a lucky courier made a day trip from London to New York by Concorde, carrying photographic film for the printed pages. Now the text is beamed as digital code by satellite link to the printer in Connecticut: only back-up copies are sent by air in an envelope. This summer, the *Financial Times* will use a satellite link between London and the US to send the editorial content in digital code at 64 000 bits of information a second, and so will be able to print simultaneously in both countries. The British Library has signed an agreement with the European Space Agency to develop the "Apollo link", an electronic document delivery service. Extracts from books stored at the British Library's lending division at Boston Spa in Yorkshire will be optically scanned, the read-out converted into digital code and beamed by satellite to dish aerials on the roofs of libraries around Europe. There the data will be decoded and printed as an exact copy of the Boston Spa text.

There is no point in converting images and text into digital code if the digits cannot be cheaply stored, easily found, and then quickly converted back into a replica of the original image and text. Equipment with these qualities must also be robust and simple to operate.

There have been predictions of gramophone records and video recordings on a chip. This is a nonsense which may create the impression that text stores on chips will be cheap. Solid-state storage remains expensive and limited in capacity, when compared with media that move physically past a record and readout station. Even a 1-megabit RAM chip, promised but not readily available, could store only one second of hi-fi stereo music in digital code. Compression techniques, which ensure that only changes in the music are recorded, reduce the number of bits needed, but the 1-megabit chip could still offer only around one minute of playing time. Without data-compression, one second of video action on a colour TV would need 100 RAM chips of one megabit each. With compression and redundant information thrown away, the number might drop to 10.



A file that records images of pages on an optical disc and reproduces them on a screen or as typed or facsimile pages

The codes for data storage use 8-bit bytes, or words, to represent one letter, digit or simple sign. A 1-megabit RAM, capable of storing 1 048 576 bits of information, can thus contain 131 072 letters of the alphabet. Taking into account spaces and punctuation, which must be also registered by stored code, even a 1-megabit RAM can hold only between 10 000 and 20 000 words of real text. This is equivalent to around half a dozen feature articles in *New Scientist*. Most important, RAMs are volatile: everything is lost when power to the chip is switched off.

Regularly, like the first cuckoo in spring, the computer industry promises cheap, non-volatile memory from magnetic bubbles. A slice of iron oxide with traces of rare earth added can store data semipermanently as a pattern of local magnetic domains. But the electronics industry has lost fortunes on bubbles, for the technology is never quite cheap enough to wean people away from using RAM, as a buffer memory, and other media for storing data in bulk.

Engineers are constantly increasing the amount of data they can record on moving magnetic media. There is no sign yet of any limit, and the process is comparatively cheap. The density of recording is directly related to the shortest wavelengths that a recording medium can resolve: the shorter the wavelength, the higher the analogue frequency and the faster the stream of digital bits the medium can capture and reproduce with accuracy. A medium capable of resolving small wavelengths and rapid pulse streams can be moved slowly under the recording head, and is thus cheaper. It also offers more efficient access, because it is quicker to search through a short length of densely packed recording than through a large area of widely spaced information.

At the turn of the century, when Danish engineer Valdemar Poulsen first recorded sound magnetically on metal strip, the shortest wavelength he could capture was one millimetre. The first magnetic recording tape made by BASF, in Germany, in the mid-1930s, could capture a wavelength 10 times smaller: one tenth of a millimetre or 100 micrometres. The first video recorders developed for broadcasting in the 1950s again improved wavelength resolution by a factor of 10. Modern domestic video recorders represent a further tenfold jump: a VHS or Beta recorder must accurately resolve signals of one micrometre wavelength to capture colour TV

signals with a bandwidth of around 4 MHz. The latest domestic machines, from Sony, use 8 mm tape to record colour TV and hi-fi sound. The wavelength capture is down to 0.7 micrometres. The original broadcast video recorders, some still used today by television stations, gobbled 12 192 square centimetres of tape a minute; the Sony hand-held portable consumes only 50 square centimetres a minute.

A video system capable of recording colour TV signals can easily cope with a digital data stream of several million bits a second. It makes no difference to the system whether the bits are encoding sound or text. For a few hundred pounds, a hi-fi buff can buy an adaptor which converts analogue audio into digital code and stores it on domestic video tape. A domestic video cassette, or one of the new digital audio cassettes expected soon from Japan, could easily offer bulk storage of computer data or digitised text at a cost per bit hitherto undreamed-of.

### Vertical magnetic particles

Philips uses similar technology to the British Library for its Megadoc office document store. Around 4 million data bits are needed to take an "electronic photograph", capturing all the detail from one finely printed black and white A4 sheet of text and pictures. The number of bits can be reduced for storage, by compression techniques which—like audio and video compressors—throw away redundant information. But even without compression, a domestic video cassette, which runs for three hours and now costs only £5, could store more than 10 000 high quality images of A4 page. With bit compression, the number rises at least 10-fold to 100 000 pages. So a single domestic video cassette, normally used to tape a film from television, could be used to store around 300 printed novels. The new 8-mm video cassette, no larger than a conventional audio cassette, has a similar capacity. So, even existing technology would allow a family to store all its books in a coat pocket.

The newest type of magnetic tape, developed for domestic video and digital audio recorders, has a very thin coating of magnetic material which is evaporated and deposited on the plastic film base. The coating is just 0.1 micrometres thick, one twentieth the thickness of a conventional tape coating. So even more tape can be spooled into a housing of standard size. This development is only a halfway house. The next generation of tape and tape recorders will exploit the technology of vertical or perpendicular recording. All existing magnetic media rely on particles which lie predominantly

horizontal or in the plane of the disk or tape. If the particles can be made to stand vertically, then density can be increased, just as it is easier to fit more people in a room if they stand up than if they lie down. Also, with vertical orientation, the magnetic particles are not so likely to demagnetise their neighbours.

Toshiba in Japan has already started to supply samples of a magnetic powder, with particles of barium ferrite only 0.08 micrometres in diameter. The powder will be used to coat tapes or disks for vertical recording. Recording density is more than 4000 bits per millimetre, which represents a wavelength resolution down to 0.25 micrometres.

For ease of access, magnetic disk storage remains a more attractive proposition than tape. The recording head can skate rapidly across the surface to any part of the data stored. This technology, too, is nowhere near its limit.

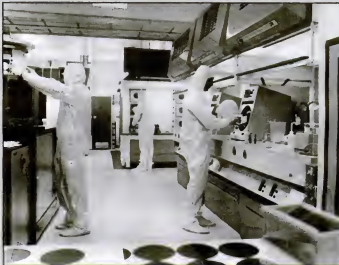
Home computers store data on floppy disks, with a magnetic coating similar to that of tape deposited on a plastic base. The best floppy disks record at a density of around 3000 bits per centimetre. This provides around 500 kilobytes (or about 500 000 text characters) on each side. Large, powerful computers use hard disks, commonly called Winchester, after the code name IBM gave the project when it was still secret. A Winchester is a rigid aluminium disc polished to mirror finish and coated with a very thin layer of magnetic oxide. A small Winchester stores around 10 megabytes. Mainframe computers dump their data into units which gang several Winchester together. The latest Hitachi disk storage unit, which in Japan costs more than 1 million yen (£3000) a month to rent, offers 5 gigabytes of memory. This is equivalent in capacity to one pocket-size video cassette. Access times are not comparable of course, but for applications where slow access is acceptable, library storage for instance, the video tape may prove suitable. Few computer enthusiasts have yet seen the possibilities. The worlds of audio, video and computing remain curiously isolated even though their technologies are closely related.

Higher-density floppy disks will soon appear on the market. The conventional coating of magnetic ferric oxide will be replaced by pure iron metal powder which can resolve more detail and thus store more information. A 9-cm floppy coated with metal particles can store several megabytes on each side. 3M in Minnesota has developed a new technology which is a cross between a Winchester and a floppy. A round disk of tough plastic material has moulded rims around the centre hole and outside edge. A thin sheet of plastics, coated with

## Why solid-state memories are expensive to make

RANDOM-access memory chips, or RAMs, capable of holding 1-megabit of information, are under development. Philips and Siemens are engaged in a joint venture, the Mega project, to develop a 4-megabit RAM—no mean feat. Philips says it will take another 3 years before production can begin.

In the 1970s microchip manufacturers were proud to produce a memory of several kilobits capacity with the circuit lines 6 micrometres apart. Today's memories, of much less than 1-megabit capacity, are mass-produced with lines 2 micrometres apart. The next generation of chips will demand the routine production of line detail below the micrometre mark. Philips and Siemens aim for 0.7 micrometres. ITT is looking at 0.5 micrometres.



Clean room suits protect the chips from slaking chip-makers. One hair is enough to destroy dozens of circuits

This is so close to the wavelength of the ultraviolet light used for lithography in chip factories that closer spacing can only be achieved by drawing the lines with an electron beam—just as an electron microscope is needed to resolve detail too small for a conventional light microscope.

With components measuring less than a micrometre, it becomes almost impossible to filter air and water to the necessary cleanliness. One speck of human hair obliterates more than 50 circuit lines. At least half the chips made are useless. The design and drawing must, of course, be handled by computer, and a program to layout a megabit chip must handle 50 million geometric details. Such complexity makes RAM chips both difficult and expensive to manufacture. □



*Tapes and floppies for photographers. The video camera (left) records on 8 millimetre tape. The stills camera (above) takes a disk—its pictures can be transmitted by telecommunications*

magnetic material, is then stretched tight as a drum over these rims so that there is a narrow air gap underneath. 3M calls the technology stretched surface recording (SSR).

The SSR disk is sufficiently rigid to spin at Winchester speed of 3600 revolutions per minute, instead of the few hundred normally regarded as safe for a flimsy floppy. The SSR head normally skims lightly over the surface. Because the magnetic coating is on a resilient skin, it does not matter if the recording head hits a speck of dirt and bounces down on the surface. A crash like this would ruin a Winchester, where the head must normally float on a cushion of air over the very thin and fragile coating. At 3M's research labs in Minnesota, cheap SSR disks running in modified Winchester drives are storing around 10 megabytes per side, equivalent to expensive hard disks.

The switch from conventional horizontal magnetic recording to perpendicular or vertical technology would increase ten fold the data storage available from floppy and SSR disks. Home computers would be able to store 100 megabytes of data on a single side of a 9-cm disk.

### Optical storage

Sony, Canon and Matsushita have all borrowed from the technology of floppy disks to make cameras which capture a still picture as a video image on miniature magnetic disk instead of on film. Prototypes were used at the Olympic Games, where photographers could send their pictures back to Japan by telephone line instead of mail or courier. When higher density disks and crisper colour pictures are available, the product will go into mass-production.

The capacity of magnetic media pales into insignificance when compared with optical storage. Philips of Eindhoven has pioneered this route, as a spinoff from its development of the laser-read video disc and digital audio compact disc. The pits pressed in the surface of a laser video disc, or audio compact disc, are less than one micrometre in size. If these pits store digital data, rather than analogue video signals, each side of a 30-cm disc can hold 1000 million bytes. With data compression, this is equivalent to the high quality images of 30 000 A4 pages. If no attempt is made to store a replica image, and instead only character codes are stored, a side of one 30-cm video disc can hold 0.3 million pages of text.

Philips, Pioneer and Sony all make video-disc players which can be linked to a home computer for interactive video. The computer controls the display of selected video sequences on the TV screen. It is often programmed by a burst of data recorded on the disc, usually in one of the sound channels. Pioneer will start selling a disc and computer system for homes in Britain this summer, for less than £1000. The first discs available will be simple games, but the hardware would work equally well at storing data and displaying it. All it needs is for someone to produce the necessary software.

As an alternative to factory pressing, optical data can be stored by office hardware which incorporates a laser to burn the pits into the surface of a pre-coated disc. Philips uses this technology for Megadoc, but has had problems with the stability of blank discs. The coating of tellurium metal, in which the recording laser burns pits, is easily oxidised in a humid environment and then becomes useless. Tellurium alloys, sealed under a lacquer, last longer. But, significantly, Philips still talks about "10-year archival life" for a medium which, because it is read by light beam, should in theory never wear out.

Both Hitachi and Philips have been developing disc coatings which change colour when exposed to a laser pulse, and are more stable than tellurium. Hitachi has coated discs with an alloy of silver and zinc which turns pink after heating above 300° C. When heated again it returns to its original silver colour. When the disc is played like an ordinary video disc, the tracking laser senses colour changes as reflective patterns comparable to those caused by the pits in a conventional video disc. Philips is working with organic dyes which change their optical characteristic when struck by a laser beam. Only a few dyes adequately absorb infrared light at the 0.82-micrometre wavelength used for recording digital data. Two dyes fit the bill; they are known as "SQS" and "TPMP". They are stable, easier to apply than metal, and readily melt in a laser beam to produce readable pits.

The development of the video disc as a data store goes hand in hand with the read-only memory on compact disc (CDROM), a joint development between Philips and Sony. A standard 12-cm compact disc normally holds around one

## From Morse code to the digital disc

THE FIRST recorded data signal came from the telegraph. Samuel Morse in the US, and William Cooke and Charles Wheatstone in Britain, simultaneously developed working telegraph systems in the late 1830s. An operator reading from plain English words keyed a sequence of long and short electrical pulses down a line. At the other end, an operator listened to the incoming pulses and mentally reconverted them back into words.

The Morse code, still used today, requires up to four pulses per letter so the operator can handle only a few words a minute. It is said that Morse got his idea from a description of an electromagnet. Whatever his inspiration, the first telegraph line in the US was completed in 1842. It ran from Baltimore to Washington. The earliest lines appeared in England about the same time and, in 1857, the first of several unsuccessful attempts to lay a cable across the Atlantic was made. A cable was not laid between the US and Britain until 1866; its quality was such that only two words a minute could be transmitted.

By the turn of the century, the speed had risen to 400 words a minute, equivalent to a data-rate of 8000 digital pulses or bits per second. Because no operator can key at this rate, the text has to be prepared in advance "off line" as holes punched in paper tape. The technique is still used today, for telex transmissions. Speed is limited to around 67 words a minute, because the equipment relies on electromechanical relays and inertia puts a limit on their

speed of operation.

The future of data storage and transmission relies on all-electronic technology, which owes its existence to Thomas Alva Edison and the phonograph which he invented just over 100 years ago. Edison used telegraph recording technology as a springboard for his phonograph. In 1877 he was building a repeater machine, which would record Morse code pulses arriving from the first leg of a long line and immediately reproduce them again down a further leg. It worked by embossing the characters



Men of data: Morse (above right) and Edison

on paper tape.

Edison found by accident that if he moved the embossed paper rapidly past a stylus, like scraping the teeth of a comb past a finger nail, the sound produced resembled



Mary Evans

human speech. This gave him the idea of recording sound as vertical indentations in tinfoil on a wax cylinder. Later he captured a bandwidth of 60 Hz to 3 kHz, which is equivalent to that of a modern telephone line. Equipment of the time could not, however, reproduce all that was recorded.

In Britain, EMI has sold pop records with a computer program on one side of the disc and music on the other. But vinyl pressings are a clumsy medium for data storage. They can be produced only by a factory press; once recorded the data cannot be erased and any wear or damage to the groove causes errors in the data stream. Magnetic, optical and solid-state storage media are far more efficient. □

hour of hi-fi stereo in digital code, but it can store computer data or text instead. A single-sided CDROM can hold 600 megabytes, which makes it equivalent to over 1000 floppy disks. One CDROM can store the entire contents of an encyclopedia and it takes on average only one second to find any datum on the disk. 3M will soon start pressing CDROM's in Wisconsin.

The combination of optical and magnetic technology provides the option to erase and re-record. NHK, the Japanese state broadcasting corporation, and KDD, the nation's international telecommunications monopoly, have been working on this approach, as have the private companies Sharp, Matsushita, Philips, 3M and Sony. A blank disc of glass is coated with an alloy of cobalt and rare-earth metal, such as gadolinium, and exposed to a laser beam modulated with the signal to be recorded. At the same time the disc is bathed in a weak and constant magnetic field. Where the beam strikes, the alloy material gets hot and switches its magnetic polarity under control of the enveloping fields. To replay the disc, a polarised beam of laser light is focused on the surface. The magnetic pattern on the disc changes the



Prototype read only memory based on the compact disc

direction of polarisation of the light reflected off the disc's surface. The difference in polarities is read by a photo cell, as in a conventional video or digital audio disc player. The signal can be erased by recording over the disc with a beam of constant power.

Although the idea of such a disc, compatible with existing video, digital audio and data storage players, sounds exciting, there are snags in practice. The coating must be amorphous, without any crystal structure. It has to be applied very slowly, by sputtering or vacuum deposition, over a period of hours or even days. The cost of magneto-optical discs is prohibitive.

When price, capacity and convenience are balanced, a clear pattern for the future of data storage technology emerges: solid-state memory for temporary buffering; magnetic discs of high density for semi-permanent storage; and optical discs for the equivalent of very high density ROM. Electronics firms are already gearing up to mass produce simple compact disc decks for other manufacturers to build into portable and cheap stereo systems. The same decks will soon find their way into home computers. Optical ROM for home computing is just around the corner. □

## SCIENCE

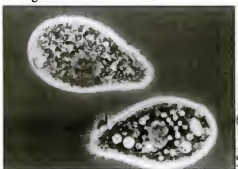
## Genetic code is not so universal

Andrew Scott

ANY TEXTBOOK of genetics or evolution will tell you that the genetic code—the relationship between the nucleotide sequence of a gene and the amino acid sequence of the protein it codes for—is universal. All creatures, from bacteria to flies to us, use the same genetic code. This neat simplicity was disturbed slightly a few years ago, when the small genomes of mitochondria were found to use slightly deviant codes—but of course mitochondria are not organisms. Now, however, some more deviations from the standard code have turned up in some free-living ciliated protozoans and mycoplasmas. So the genetic code is really not universal after all (*Nature*, vol 314, p 132).

The deviations from the standard code, which five separate groups of scientists in America, Europe and Japan have now found, are very small. In each case a series of three nucleotides (a codon) which normally marks the point on messenger RNA at which protein manufacture should stop, instead codes for the incorporation of an amino acid. But they are deviations from a major biochemical doctrine—sufficient to prompt Thomas Fox of Cornell University to declare “the notion of universality will have to be discarded.”

Sydney Brenner, head of the Molecular Research Council's Laboratory of Molecular Biology at Cambridge, and contributor to the breaking of the standard code, is more cautious: “Certainly these discoveries are very important and interesting,” he offered, “but they are not revolutionary.” Brenner emphasised that the deviations found so far are all very minor variations on the standard and still universal theme, rather than entirely novel codes in which all or most of the codons have their meanings changed.



*Tetrahymena: a chink in universality*

The main significance of these new discoveries concerns our version of early evolution. Current textbooks often state, not only that the genetic code is universal, but that it has to be universal; because any alteration of the code would destroy the organisms concerned by wrecking all of their vital genetic messages. Such reasoning is based on the assumption that all modern life is derived from a single ancestral line in which the standard genetic code was already fixed. The modern code has been described as a “frozen accident”, chanced on by the first life and then fixed forever because changes would cause damage.

So what are we to make of the discovery of slightly altered versions of the code? It probably simply means that the organisms concerned diverged from the common stock at an early stage; and that some geneticists have been overly dogmatic in asserting the inevitability of a universal code.

So it is likely that other remnants of perhaps even more ancient lines of evolution have survived? Completely different codes would be a major shock and there are absolutely no signs of them so far. But it does appear that the “frozen accident” may have experienced the occasional thaw. □

## Chinese archaeologist discovers Shang capital

RECENT archaeological discoveries in the People's Republic of China are enlightening researchers about the early development of the Shang dynasty.

This civilisation, with its highly skilled bronze metallurgy, elaborate writing system and jade carvings, was the first of the great dynasties recorded in early Chinese texts. The Shang dynasty is believed to have held power in north China for seven centuries from about 1700 to about 1100 BC (or about 1030 BC according to a revised chronology). Ruins of Xibo, the capital of the first Shang emperor, Cheng Tang may now have been found in Yanshi county, in the Henan province according to Professor Xia Nai, Vice President of the Chinese Academy of Social Sciences and Honorary Director of the Institute of Archaeology in Beijing.

Professor Xia Nai spoke of the discovery of a large walled town dated to about the sixteenth century BC at the jubilee celebration conference of the Prehistoric Society, held in Norwich at the end of March.

By a happy coincidence, it was also the 50th anniversary of Professor Xia Nai's first visit to Britain. He came over in 1935 as a student and helped Sir Mortimer Wheeler excavate the Neolithic and Iron Age site of Maiden Castle in Dorset.

By another coincidence, this year sees the resumption of archaeological work at Maiden Castle to mark the World Archaeology Congress in Southampton in 1986.

Professor Xia Nai served his archaeological apprenticeship in the 1930s at the famed site of Anyang, the last capital of the Shang dynasty, in northern Henan. The new site, discovered in 1983, lies just south



*Bronze ritual vessel of the Shang dynasty*

of the Yellow River (Huang He) a few kilometres from another Shang town, at Erlitou. Excavations at Xibo continue, but Chinese archaeologists have already found the remains of a wall built of compressed earth, gateways through it and foundations of three large buildings, and they have been able to trace several of the town's main streets.

In another of the presentations at the Norwich conference, Colin Renfrew talked provocatively about the origin of the Indo-European languages. Renfrew, Disney Professor of Archaeology at Cambridge, believes it high time that experts in European prehistory began questioning the established school of thought that places the origin of this large group of languages in the south Russian steppes around 3500 BC.

He argues that the Indo-European languages, which include most modern European languages, Farsi (spoken in Iran), Sanskrit and its descendants in the northern part of the Indian subcontinent and Linear B (an early form of Greek), are all related. But the view that thousands of nomadic people speaking Indo-European swarmed out of the Russian steppes he dismisses as “highly implausible”. The myth of the dispersal of the Indo-European languages in the Bronze Age “should be laid to rest”, Renfrew said. It was a Neolithic phenomenon.

Renfrew's model is that a proto-Indo-European language spread from Anatolia with the dispersal of the first farmers about 9000 to 8000 BC. There was language replacement as large numbers of people speaking early Indo-European gradually moved east and west taking cereals and other domesticated plants with them. Thus, according to Renfrew, an early form of Indo-European was spoken by the first farmers of Greece; Celtic and the Germanic languages originated from the language that groups of Indo-European-speaking farmers introduced to northern Europe.

Sarah Bunney

## Malaria parasites

MALARIA parasites can propagate in red blood cells that are deficient in an enzyme they need for producing the missing enzyme. The enzyme is glucose-6-phosphate dehydrogenase (G6PD). Women with a certain X-linked chromosomal disorder cannot produce this enzyme, and because the malaria parasites rely on the enzyme for their development, its deficiency protects some women against the disease. But E. A. Usanga and L. Luzzatto, of the Royal Postgraduate Medical School, in London, have found that malaria parasites can produce their own G6PD (*Nature*, vol 313, p 793).

The parasites invade both the normal cells and the G6PD-deficient cells, and gradually adapt to the G6PD-deficient cells by producing increasing amounts of their own enzyme. They thus possess the gene for this enzyme, but are unable to express it in normal red cells.

The study shows that the expression of a parasite's gene can be determined by the host cell. But it also provides insight into how the malaria parasite might cope with other red cell deficiencies, and even antimalarial drugs. □

## Troops could spread disease

MOVEMENT of troops on the Brazil-Venezuela border could lead to a spread in the virtually-incurable disease, onchocerciasis. The disease is transmitted by tiny, blood-sucking, blackflies which infect their victims with small parasitic worms that produce blindness and skin disorders.

Onchocerciasis is well-known in West Africa, where the World Health Organisation has been spending millions of dollars over the past decade in attempts to control the trans-Atlantic river. In Latin America, the disease occurs in small areas of Guatemala, Mexico, Ecuador, Colombia and Venezuela. In 1967, it was found around the borders of southeastern Venezuela and northern Brazil. The disease is hyperendemic in isolated villages of the Yanomami and Maingong Indians, and is, so far, confined to these areas. In the 1970s, a branch of the trans-Atlantic highway was pushed towards the periphery of the region, bringing fears that the Indians would use the highway, and spread the disease. But the construction stopped in the mid-1970s oil crisis.

Now the Brazilian air force has moved its advance base into the region, and the army has extended its network of border posts through the main onchocerciasis area. □

## Big buzziness

IS THERE no limit to the utility of honey bees? In the US they yield more than \$100 million of honey and wax annually and pollinate billions of dollars-worth of crops. Now they are set to rise to prominence in the field of pollution monitoring (*Science*, vol 227, p 632). Foraging bees pick up pollutants, nectar and pollen, or even contaminated dust mistaken for pollen, and ferry it back to their hives. They may also take in contaminants in their diet. Back at the hive, polluted air is circulated by worker bees with air-conditioning responsibilities. The level of pollutants in the hive can reflect the level of pollution in the surrounding countryside. It may prove cheaper and more effective to monitor beehives than to use expensive air sampling techniques or tedious soil sampling.

J. J. Bromenshenk and colleagues at the University of Montana enlisted the help of 64 beekeepers with hives in the Puget Sound region of Washington State. They analysed frozen whole bees for lead using an ion-specific electrode and for heavy metals by atomic absorption spectrophotometry.

Concentrations of zinc, lead and copper were not related to pollution sources. But fluorine, arsenic and cadmium concentrations showed patterns similar to those plotted by regulatory agencies on the basis of soil concentrations, that is highest around industry. Tacoma and low in the rural hinterland. So the message to the polluters is clear, beware the bees. □

## Disruption is attractive

THE LEK, or area reserved by birds such as the cock of the rock (*Rupicola rupicola*) for courtship rituals, seems at first sight a relatively peaceful sexual super-market. The males of a variety of species of bird, such as the prairie chicken and sage grouse of North America, and even some



insects, make their way, at the start of the breeding season, to traditional lekking sites. They take up stations in the communal display area and perform a series of elaborate movements and vocalisations.

Each male clears a display ground roughly 1 metre across and about 1.5 m from his nearest neighbour. Females visit a few male territories over a period of two or three days and then choose a male to mate with. As in all leks, male success is highly skewed, with most of the matings going to a few of the males; a single male accounts

for 30 per cent of the matings each season, and two-thirds of the males fail to get any matings.

All is not quite as it seems though. During a four-year study of these birds in the dense rainforests of Surinam, Pepper Trail of Cornell University noticed that roughly one in every three courtship visits and matings was disrupted by the interference of another territorial male. Trail had a large enough sample to ask what the consequences of this behaviour might be for the female and the two males, disrupter and victim, and presents the results in *Science* (vol 227, p 778).

If a hen bird is disrupted on her first mating she goes on to visit more males and to mate with more than one of them. This means that the reproductive success of the male victim is reduced. The disrupter, however, is not merely being spiteful, he is enhancing his own reproductive success. Disrupter males obtain more matings than non-disrupters and, because disruption as a strategy is not limited to the most successful males, this indicates that it is not simply those males that are most attractive to females that are also most disruptive.

It could be that disruption focuses the female's attention on the disrupter himself, or that it simply forces the female to choose again. Trail discovered that males that are actively and persistently disruptive did attract to themselves the females they had interrupted.

If disruption is such a good strategem for getting matings, why is it not more common in the cock of the rocks' leks? Perhaps because the more time a male spends disrupting others, the less he has for display and attraction on his own ground. □

## Quantum effects explain how we hear

WHAT determines the smallest sounds we can hear? Studies by two American scientists suggest that quantum effects in the inner ear set the lower threshold for hearing. Their findings led the researchers to propose a new hypothesis to explain the mechanism of hearing.

The inner ear contains a spiral canal, called the cochlea, which is divided into two along its length, and filled with liquid. The partition along the canal contains receptor cells, which are surrounded by nerve fibres connected to the auditory nerve. Sound waves change the pressure in the fluids in the inner ear and cause minute movements in tiny hairs, a few micrometres long, on the receptor cells. These movements trigger the nerve fibres so that the brain "hears" the sound.

Measurements on cats, bats and other animals indicate that the smallest displacements that can produce the sensation of hearing are about  $10^{-11}$  metre—smaller than the dimensions of a single atom. The equivalent sound energy is as small as  $10^{-18}$  Watts.

Now, William Bialek and Allan Schweitzer both at the University of California, have calculated the "noise" due to quantum effects in a "fictitious inner ear operating at absolute zero" of temperature (*Physical Review Letters*, vol 54, p 725).

According to quantum theory, even at absolute zero any physical systems has residual "zero point" fluctuations with an associated energy. Knowing the physical properties of the receptor hairs, Bialek and Schweitzer calculate the movement equivalent to the quantum "noise", and find that it is in the region of  $10^{-11}$  m—in other words, the same as the minimum movement for hearing.

However, the researchers also calculate that thermal motions, at temperatures above absolute zero, give rise to much larger amounts of energy than the quantum noise. So how does the ear in a sense ignore the thermal noise, and instead hear down to the level of the quantum noise? Bialek and Schweitzer say they are "forced" to conclude that the hair cells are not in equilibrium with their surrounds—otherwise the cells would be sensitive to thermal noise.

The researchers argue instead that some "feedback" mechanism in the inner ear must keep the system in a non-equilibrium state. The properties of such a mechanism have important implications for theories of hearing, and rule out many if not all existing models. If Bialek and Schweitzer prove right, any theory of hearing must involve quantum effects. "There is no consistent classical theory of hearing", say the researchers. □

## Variety is the spice of famine relief

IN THE refugee camps of Eastern Sudan there exists a paradox: people there have very little food yet they complain of lacking appetite. Studies by Edmund Rolls and colleagues at the University of Oxford not only help to explain this paradox but has important implications for relieving famine (*British Medical Bulletin*, vol 37, p 131).

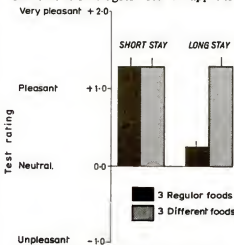
One possible solution is "sensory-specific satiety". Rolls and colleagues investigated neuronal control of feeding in primates and found a group of neurons in the hypothalamus which respond to the sight and/or taste of food. In monkeys fed to satiety on one food, these neurons cease to respond to the sight or taste of that food, yet continue to respond to the sight or taste of other foods on which they have not been fed.

Correspondingly, in human beings, satiety is specific to the taste and/or sight of particular foods. After eating one food to satiety, the pleasantness of that particular food declines relative to other foods that have not been eaten.

Refugees in Eastern Sudan are fed a very monotonous diet. The World Food Programme (WFP) aims to supply a "minimum ration" consisting of a daily food basket of 300 g of millet, 30 g of edible fat, 30 g of pulses and 40 g of dried skimmed milk. There is also, occasionally, supposed to be meat and small amounts of sugar, salt and spices. But in the refugee settlement where Rolls carried

out the following study, refugees received only millet, 17-23 g of beans and milk each day, often no edible fat, and almost never any meat, salt, sugar and spices.

Could it be that this diet is so monotonous that the refugees lose all appetite



Food, if varied, tasted better for longer

for eating the food provided; that they are the victims of long-term sensory-specific satiety?

Rolls and colleagues performed an experiment to test this hypothesis at the Um Rakouba refugee settlement in Eastern

Sudan last July. Of 48 Ethiopian refugees, 24 were fed the WFP diet for six months, the rest ate it for only two days. Six foods were given, three supplied by the WFP, and three other novel foods specially chosen as to be comparable to the WFP foods. The subjects were given a mouthful of each and asked to rate the pleasantness of each on a five-point scale. The results show that eating a limited set of foods for a long period reduces the palatability of these foods relative to that of other foods (see Figure).

There are important implications for feeding in refugee camps and other places where little variety of food is provided. Food supplied by relief agencies is often traded with non-refugees in the surrounding area to obtain other items so as to vary the diet. Market forces mean that refugees buy relatively small quantities of less nutritious food, or even non-food items such as tobacco. If refugees are fed a more varied diet, and variety could be created either by increasing the number of foods supplied or by providing a range of spices, then the worst effects of long-term sensory-specific satiety may be overcome: the food-aid recipient will have his or her appetite restored. □

The researchers wish to thank the Office of the Commissioner of Refugees for its assistance and cooperation.

## FUNDING FOR BIOTECHNOLOGY

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# Filariasis kills mosquitoes too

Steven Lindsay

**M**OSQUITOES, for most people, are evil. Not only are they a physical nuisance but they are also harbingers of death through disease. It may, however, come as a surprise to learn that mosquitoes can also suffer from the diseases they transmit, particularly in the case of lymphatic filariasis.

Mosquitoes become infected with worms when feeding on the blood of an infectious human. Adult female worms can produce thousands of young worms (microfilariae) which pass out of the human lymphatic system into the peripheral blood and then into the stomachs of feeding mosquitoes. The microfilariae begin tearing their way through the insect's stomach using a small tooth at their anterior end. Eventually these worms push their way between the fibres of the flight muscles within the thorax, becoming quiescent before undergoing further development.

In this way, large numbers of microfilariae can kill a mosquito within hours of feeding on infected blood. Needless to say, those mosquitoes surviving this traumatic event are unable to fly properly.

Mosquitoes are not completely defenceless, however, and many species have evolved an arsenal of weapons specifically designed to protect against the ravages of the worms. Some species have tooth-like structures in the head (cibarial and pharyngeal armature) to defend against microfilariae taken up with a blood meal. These teeth ensnare and damage many of the worms that are imbibed. Some mosquitoes

insects are less fecund and many have difficulty in feeding. Sick mosquitoes take longer to settle and feed and some find it difficult to penetrate the skin with their stylets. Intuitively, one might expect that the general ill health and lack of coordination shown by these insects is also due to the presence of such large worms moving about within the head capsule. This may be responsible for the "punch-drunk" condition of some infected mosquitoes.

The transmission of infective larvae from mosquito to human beings can be likened to the scene from the film *Alien* where the parasite bursts from the body of a dining astronaut. In this natural example, worms burst from the bottom lip of the mosquito while it is feeding. In a frenzy of activity the infective larvae pour onto the surface of the skin, which is covered in blood (haemolymph) from the mosquito. Not surprisingly, a number of mosquitoes seem to find this expulsion of worms rather disturbing. Sometimes this may interrupt feeding so that the mosquito removes its stylets from the skin and begins to wander over the skin's surface. If this occurs the mosquito may continue to spew worms over the skin. The larvae are, however, unable to infect the host because worms cannot penetrate intact skin.

Mosquitoes may attempt to "clean" their proboscises with their forelegs to rid themselves of worms. On one occasion I witnessed one unfortunate individual catch one of its front legs on a loop of worm.

It then remained imbedded in this undignified position for several minutes before it eventually freed itself.

Fortunately for us, these detrimental consequences of parasitism constrain the growth of the mosquito population. This effect is usually manifest in mosquitoes that are heavily infected.

Filariasis is therefore a disease of mosquitoes as well as of human beings. From a biological, and decidedly non-anthropocentric, perspective it is the mosquito that suffers most. But this is part of the high price a mosquito must pay in order to obtain a meal, sufficiently rich in protein, from which it can produce eggs and thus pass its genes to the next generation. □

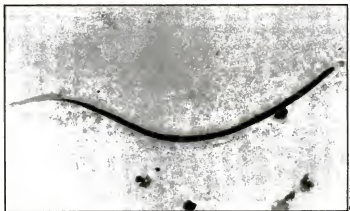


Figure 1 Mosquitoes can become infested with microfilarial worms such as this one



Figure 2 The proboscis of a mosquito

## The worms that cause elephantiasis

**L**YMPHATIC filariasis is a debilitating disease caused by filarial nematodes which are transmitted by mosquitoes. Over 90 million people throughout the tropics, are thought to have lymphatic filariasis at present. In addition, more than 900 million people live in areas where they risk contracting the disease. What is even more disturbing is that filariasis is progressively becoming an urban problem and is increasing, despite vigorous attempts to control it during the past 40 years.

The adult worms lodge in the lymph vessels and nodes, usually of the lower limbs, and may cause such irritation

that extensive areas of scar tissue result. Ultimately this may give rise to the horrific deformities characteristic of elephantiasis (Figure 3). Elephantiasis is a consequence of continual and intense infection and is, fortunately, relatively rare.

In contrast, the early signs of filariasis are common. These include headache, fever and acutely painful swellings of the affected lymphatic vessels. During the Second World War, over 27 per cent of US naval servicemen contracted filariasis while fighting in the South



Figure 3 Filarial nematodes can cause elephantiasis

Pacific. Some took as little as three months to develop the first signs of the disease. □

# TECHNOLOGY

## Taking the heat out of glass making

**M**AKING materials such as ceramics, fibres and glass at low rather than high temperatures has intrigued scientists for the past 25 years. So far fibres and thin protective coatings have been made successfully. Now, Larry Hench, from the Materials Science and Engineering Department at Florida University, says he can make large glass structures without first heating them to 1000°C.

The technology that Hench is using is known as sol gel. Several Japanese companies, as well as ICI, in Britain, have worked on the technology. ICI made fibres by the technique, but the Japanese have studied glass making at low temperatures. The problem has always been that large structures crack as they are dried. This is because of their structure and the chemistry of the process.

What happens is that water is added to a precursor such as tetramethoxysilane. The first stage is hydrolysis of the silicon to give silicon hydroxide molecules. These individual molecules then polymerise to give a three dimensional structure of silicon oxide. Each silicon molecule is initially bound to four hydroxyl molecules. During the condensation process, two silicon hydroxyl bonds give a silicon bond, plus water. Because, the silicon atom has four such bonds, the structure builds up in three dimensions. The problem is that the first silicon hydroxyl bond is broken faster than the last three. This means that, instead of a perfect three-dimensional structure, polymerisation occurs in limited areas or in a particular direction. Water from the condensation reaction is trapped in gaps which exist because of this irregular formation and causes stress that cracks the structure. Also the gel, because of its irregular structure does not shrink uniformly when it is dried, and again, cracks are caused.

Hench has succeeded in slowing down

Helen Gavaghan

the condensation process so that the polymer builds up uniformly in all directions to give a tetrahedral structure. He achieved this with a chemical additive.

He believes that this additive forms weak hydrogen bonds with the hydroxyl molecules, and enables all the silicon oxide bonds to be formed at the same rate. Hench claims 100 per cent reliability with his method. Yet it was not clear sailing all the way. The first chemical blocking agents he

all a blank made from vitrified silica is needed. Blanks, which are optically good, are selected then ground and polished to give an extremely smooth surface. This grinding and polishing can take years. Any irregularities on the surface will interfere with the high-resolution image that the astronomer must obtain.

Hench's idea is to pour gel into specially prepared moulds which when dried will give astronomers the high precision glassware they need without the time consuming polishing and grinding.

Once it is dried, the sol-gel glass remains physically and chemically stable up to 650°C. If it is heated above this temperature, certain properties, such as hardness, refractive index and elasticity, are altered in a controlled way. "The advantage," says Hench, "is that designers can select what optical properties they require, and the glass can be heated to the temperature needed to modify its physical properties to particular specifications."

Hench's work was funded by the US Air Force Office of Scientific Research. His brief was to work on materials that could be made into large structures in space. One of the constraints faced in space is the lack of large amounts of energy. The sol-gel process requires far less energy than conventional glass making techniques.

At a conference, held in Florida in March, delegates discussed potential applications for the material. One possibility that was discussed was to make the complex honeycomb catalysts used in industrial processes.

Professor Derek Birchall, from ICI's laboratories in Runcorn, which developed fibres made from the sol-gel technique, says: "There are no commercial applications for the product yet, but it could be important for casting complex three-dimensional shapes with specific physical properties." □



Casting Glass Works

A new glass could cut out the extensive polishing and grinding needed to make telescope mirrors

added to the precursor and water slowed down the condensation reaction, but the resulting structure was unstable in the atmosphere.

There are six stages to the sol-gel process. The first is to make the solution of precursor, additive and water; the next is mixing, followed by casting, gelation, ageing and drying at temperatures between 20° and 150°C.

Casting is the stage which makes Hench think that the glass will find applications. For example, a high precision mirror for a telescope takes a long time to make. First of

**T**INY CHROMIUM particles were the cause of engine trouble among British Rail's 200 kilometre/hour high-speed trains (HST). The spate of HST breakdowns reached a peak in the hot summer of 1983, when on lines running west out of London there were not enough HSTs to run the service. The high-speed trains had to be replaced by slower trains running at 160 km/h.

British Rail and the HST's engine makers, Paxman Diesels, asked Brunel University to look at the pattern of cylinder liner wear, which was extremely unpredictable. The research began in 1979 with the analysis of engine oil from two HSTs, one

which had low cylinder liner wear, and one high wear.

The analysis revealed a high level of chromium particles in the engine oil of the HST, ranging in size up to 50 micrometres. The source of these particles was the chromium plating on the engine cylinder itself. Brunel established that wear occurred because some of the chromium plating on the cylinder liners had loose particles. During the course of running these particles became detached and entered the engine oil. In HSTs with high engine wear, the chromium particles reached a peak after about five months.

These chromium particles scuffed the

plating on the liner and caused the high wear. The HSTs which had low rates of wear had better quality chromium plating, with fewer loose particles.

The solution to the problem was to change the manufacturing process of the cylinder liners so that the number of loose particles in the plating, and the number which were only weakly attached, was kept to a minimum.

These changes have completely removed the variability in wear, according to a paper given at the Institution of Mechanical Engineers last month. British Rail has extended the time between overhauls for its HSTs from one to two years. □

## Seaweed's clue to a cure for cystic fibrosis

A CHEMICAL, currently extracted from seaweeds and widely used in the manufacture of food, may hold the clue to new treatments for cystic fibrosis. Genetic engineers at the University of Chicago have succeeded in getting a microbe to produce large quantities of alginic acid.

Alginic acid occurs in high levels in the lungs of people suffering from cystic fibrosis. An understanding, achieved by experiments in genetic engineering, of how this chemical is produced by sufferers could lead to new treatments for the disease.

Cystic fibrosis is a genetic disease that occurs in one in 1600 people born in the U.S. One in 20 people in Britain carry the recessive trait for the disease. The bacterium *Pseudomonas aeruginosa* produces alginic acid, but only under certain conditions, in cystic fibrosis, for example. The disease affects many organs, but patients

usually die of a massive pseudomonas infection, and as the disease gets worse the bacteria produce more alginic acid. The gummy polysaccharide interferes with the normal function of the lungs and must be removed by painfully slapping on the back several times a day.

The Chicago team lead by Ananda Chakrabarty postulates that manufacturing the polysaccharide presents an enormous energy burden to the normal cell, and that genetic controls usually keep the genes that produce alginic acid turned off. So the pseudomonas strains isolated from fibrotic lungs provide a unique and stable strain of bacteria, in which the alginic acid genes are permanently switched on. In the lungs some, as yet unknown, condition seems to favour the growth of these strains over the normal ones.

By studying the genes controlling the

metabolism of alginic acid in these microbes, Chakrabarty's team isolated the characteristics which controlled stability in the bacterium. They produced a stable line of genetically engineered pseudomonas bacteria which also manufactured alginic acid continuously. It is this special line of pseudomonas bacteria which could provide unique insights into the disease of cystic fibrosis.

"By understanding how these genes are turned on in cystic fibrosis, we may be able to come up with a drug that turns these genes off," says Chakrabarty. A closer study of the enzymes involved in the synthesis of alginic acid (phosphomannose isomerase, for example), could lead to the development of non-toxic inhibitors which could be inhaled from an aerosol spray to prevent alginic acid formation.

● Chakrabarty's team also studied another biochemical pathway which could benefit the food industry. Alginic acid is a substance widely used as a thickener in the food industry. The genetic engineers in Chicago think they have found a way of varying the properties of alginic acid almost to order. Alginic acid consists of varying quantities of two components, manuronic acid and guluronic acid. The ratio of these two molecules governs the viscosity of alginic acid. The conversion of manuronic acid to guluronic acid is controlled by an epimerase enzyme. The final viscosity of the polysaccharide depends how much enzyme is available to convert manuronic acid to guluronic acid, and so vary the viscosity.

Chakrabarty's team plans to use a variety of genetic engineering techniques to insert a high number of copies of the gene coding for epimerase into the stable strain of *pseudomonas aeruginosa*. Chakrabarty says that by controlling the number of epimerase genes it will be possible to get different degrees of polymerisation and thus a new range of polysaccharides. □

## Ballistic electrons for improved radar signals

RESEARCHERS at Cornell University, New York, are working on analogue chips, which they claim, could increase the capacity of satellite receivers and transmitters 10-fold. The chips achieve this increase by enabling satellites to operate at higher frequencies than are possible with present electronics.

The key to Cornell's work is a phenomenon known as the ballistic electron effect, first put forward by Lester Eastman, of the university's School of Electrical Engineering in 1977. Eastman claims that the effect can be used to build semiconductors which switch at 1.5 picoseconds, compared with the present record transistor switching speed of 11 picoseconds held by Bell Laboratories.

Cornell's research is funded by the US Department of Defense which wants fast circuits to amplify and analyse radar signals. The technology could also be applied to satellite electronics in which the ability to operate at frequencies above 30 000 megahertz is restricted by the switching speed of the amplification circuits. Eastman reckons that so-called ballistic transistors would be fast enough to cope with frequencies of up to 94 000 megahertz.

Signals transmitted in the millimetre range (above 30 000 megahertz) only require small receiving antennae—an important advantage for faster switching speeds.

The ballistic electron effect is not fully understood. Eastman argues that given pure semiconductor materials, very small devices and some kind of a "launcher", it is possible to accelerate electrons to speeds up to 15 times those possible in conventional silicon circuits. The added velocity is a combination of the initial boost and, apparently, fewer collisions with other electrons along the way. The electrons are speeded up further by applying an electric field across their path. The faster electrons travel, the faster the switching speed of a transistor.

Cornell has constructed several ballistic transistors out of gallium arsenide compounds, which operate at up to three times the speed of their silicon counterparts.

Instead of slowly accelerating between the source and the drain of the transistor, the electrons in Cornell's device are "launched" by a "heterojunction". A heterojunction is the meeting point of two different semiconductor materials, in Cornell's case gallium aluminium arsenide and gallium arsenide. An energy, or band gap, exists at the point where the two materials meet, so that as an electron crosses it, the electron speeds up rather as though it had been thrown off the side of a bridge.

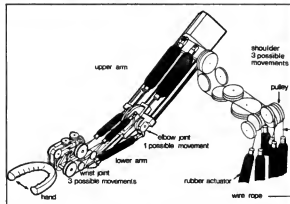
Eastman maintains that ballistic transistors will eventually prove to be so fast that other components in processors built from them will not be able to keep up. The transistors will have to be slowed down. Eastman himself seems to have got ahead of some of his co-workers. His idea of the ballistic electron has yet to be backed up with a theory which explains the phenomenon. □

## Rubber arms for more movement

ROBOT manufacturers are turning their attention to rubber as a material to produce "muscles". One robot with a rubber "muscle" is described in the *Journal of the Malaysian Rubber Research and Development Board*. It was developed by the Bridgestone Corporation and Hitachi in Japan.

The robot arm has simulated wrist, elbow and shoulder joints with seven degrees of freedom—three in the shoulder, one in the elbow and three in the wrist. There is also a rubber gripper on the end of the arm.

The "muscles" which control the arm movement are made of hollow rubber tubes covered in a braided fibre. The tubes are closed in one end. When compressed air is pumped into the tube, it contracts along its length and expands outwards. One end of the tube is in a fixed position and the other is attached by a wire over a pulley to another tube.



Rubber tubes and compressed air give robots more ways to move

Contraction of the tube pulls the wire round the pulley and causes the joint to move in a particular direction.

The arm, which weighs 6 kilograms, can handle 2-kilogram loads. And the rubber gripper opens and closes under the control of a microchip. □

## Scientists seek cheap ways to combat parasites

**S**HEETS of black cloth, insecticide, a metal frame and jars of chemicals are proving effective in eliminating tsetse fly from the banks of the Zambezi in Zimbabwe. The work, based on research by Professor Einar Bursell and Dr Glyn Vale, of the Bristol Tsetse Research Centre, was reported at the inaugural meeting of the new Wellcome Tropical Institute.

A team working in Zimbabwe, stretched black cloth impregnated with pyrethrin insecticide over metal frames. Two open jars containing attractant chemicals, isolated from cattle by the Bristol team, were put under the frames. By adding acetone, the chemicals were made more volatile.

One screen was placed per four square kilometres over a 600 square kilometre area next to an infested wooded region. The project began last September. Within a few weeks the numbers of tsetse flies had declined to 0.3 per cent of the original numbers on the border—the most heavily infested area—and to 0.1 per cent of less in the interior of the controlled area. The technique costs less than the cheapest alternative method—ground water spraying (*New Scientist*, 4 April, p. 7). But it can be made even cheaper, because results show that the screens do not need to be so closely spaced. Also, chemicals which will increase the screens' "pulling power" have been discovered at Bristol.

In Mali and Tanzania, Chris Curtis, from

### John Newell

the London School of Hygiene, has been combating mosquitoes with nets impregnated with the latest pyrethrins. The pyrethrins have a rapid effect. So rapid that the nets keep out mosquitoes even when, as tends to happen, they have small holes which, without insecticide impregnation, let mosquitoes through the netting. The pyrethrin lasts six months before the nets need to be reimpregnated. Impregnation and the tailoring of nets can be done in villages. Curtis has also shown that wrapping 10 centimetre strips of cotton impregnated with pyrethrin round ankles stops 85 per cent of mosquito ankle biting. In a separate project, he showed that polystyrene beads floating on latrines prevent mosquitoes from laying eggs. Tests in Dar-es-Salaam show the beads are effective for up to three years.

Another success was reported to the meeting by Anthony Sebastian. Sebastian works in Rangoon in Burma. He put out oil drums, the most common form of storage for domestic water supplies, to watch mosquito larvae breed, and found none. A search revealed that the drum contained two dragonfly larvae which ate all the mosquito larvae. Over 90 per cent of mosquitoes responsible for spreading dengue fever breed in domestic water supplies in such drums.

Sebastian got local people to collect dragonfly larvae and put them in pairs in 400 oil drums infested with mosquito larvae. In two weeks no mosquito larvae were left, and six weeks later there were no mosquitoes in the area. The dragonfly larvae went on working because they are able to live without food for several weeks after gorging themselves, and can wait for more eggs to be laid. Dragonfly larvae are easy to collect from known breeding areas, and the dragonflies could be encouraged to breed where required.

At an earlier stage, but with equal potential, is a method of controlling the spread of Chagas disease in Central and South America. It was devised jointly by Chris Schofield of the London School of Hygiene and the Overseas Section of the Building Research Establishment (BRE). The Chagas parasites are spread by bugs which live and breed largely in cracks in the walls of houses built from dried mud.

The BRE developed a hand-operated, hydraulically-assisted machine which compresses earth into hard bricks bound with ordinary lime. Hard bricks made in this way do not shrink or crack, and so eliminate bug breeding places. Residual pesticides spread on these bricks last three times as long as they do on ordinary dried mud floors. The machine costs £1200 and has proved effective in the Yemen. □

## Doctors recirculate blood from wounds



*Doctors in the US are rethinking the idea of transfusing blood taken from a patient during an operation back into the patient during the same operation. In this way they hope to combat blood-borne diseases such as AIDS*

**P**EOPLE'S FEAR of catching AIDS and other blood-borne infections is prompting doctors to resurrect an old method of transfusing blood. The technique is known as autologous blood transfusion.

In its simplest form, patients who need surgery, but whose blood is of a rare type, can build up a store of their own blood in a hospital blood bank before an operation. A more advanced approach is to salvage blood as it flows away from the wound during surgery, and pump it back into the patient. The idea was first thought of nearly 160 years ago, but the results were disastrous. In the 1970's a pump-based system was tried, but this, too, was unsuccessful, because the pump mechanism put air bubbles into the blood which resulted in lethal embolisms in the patient. But these problems have been largely eliminated in the current generation of machines used in American hospitals.

First of all, the blood is sucked from the

wound and mixed with an anticoagulant agent. Then the blood is washed and centrifuged in saline solution. The red cells are thrown outwards, while plasma and platelets are drawn towards the centre of the centrifuge bowl. What comes out of the machine, and is fed back into the patient, is a dilute solution of red blood cells. In this way, the machine can process blood at the rate of 200 to 300 millilitres per minute.

However, in major surgery, blood loss can be quite sudden, and there may be more blood around than the cell washer can handle. To cope with this, blood is stored in a series of cannisters. In these cannisters there are microfilters which pick up microaggregates, such as clots and fragments of tissue from the wound. The filtered blood can be washed in the centrifuge, or fed back into the patient. The technique is particularly useful for reclaiming blood from the oxygenating machine needed for open-heart surgery.

The method is not without its problems. Some doctors express fears about its use in emergency surgery. For instance, in a shooting where the intestine is punctured and the contents contaminate the blood. And in surgery where cancerous tissue is removed, there are fears that the technique could seed cancer cells in other parts of the body. □

### Ultrasound guides injections

**F**INDING a blood vessel can be a trying experience for the doctor and a painful one for the patient. And blood vessels can be permanently damaged in the process. This problem, however, could be a thing of the past. Peter J. Kolb, of the University of Capetown Medical School, has developed an ultrasound guided needle to puncture blood vessels.

Although the idea of using ultrasound is not new, previous attempts failed because the only puncture that could be made was at right angles to the vessel, whereas, the preferred angle of approach is between five and 30 degrees. Kolb beams ultrasound from two transducers at the patient. If a blood vessel is present at the point where the two beams intersect each other, then a tiny loudspeaker on the needle guide beeps to indicate this.

The needle is mounted adjacent to the transducers on the guide. A mechanical drive ensures that the needle is positioned so that it bisects the angle between ultrasound beams, and is aimed right on the blood vessel. The prototype guide has been used on a number of occasions, but Kolb feels it is still a little too unwieldy. He is working on the production of a smaller device. □

## Nuclear safety need a rethink

John Bell

IT IS NECESSARY to understand how people make mistakes to prevent the human errors that lead to disasters in nuclear power stations, the British Psychological Society was told last week. At the moment, engineers consider the people who run complex systems of all kinds as components that may or may not go wrong. This view is no longer sufficient, the society's annual conference was told.

The suggestion came from James Reason, a psychologist at the University of Manchester. "Murphy's law really screws you when you design a complex system," he says. "Intelligent people will work out how to prevent a system failing, but the operator will find a way to cock it up."

Reason believes that people do not make only one type of mistake. They make different kinds: those concerning routine tasks; those involving a familiar problem and those that happen when a new problem appears. Reason calls these skill-based, rule-based and knowledge-based errors respectively.

He relates each error to a cognitive process. Skill-based errors happen at the intuitive, or automatic, levels of thought before the mind is conscious of the mistake. Once the operator is conscious of the error, then it becomes rule-based and can be solved by applying the lessons of past experience. If experience cannot correct the mistake, then it is knowledge-based, and it will require time to work it out. The disaster at Three Mile Island was caused by a knowledge-based error. The operators could not work out what was going on until it was too late.

The least dangerous errors are most likely to happen at the intuitive or skill-



Engineers might make fewer mistakes if banks of dials were replaced with graphics

based level. Reason argues that the controls of nuclear plants, and other complex mechanisms, such as helicopters, or chemical processes, should be designed to keep errors at the skill-based level.

"Systems need to be made transparent to the operator. We can do this by presenting information in a way that the human brain can handle," says Reason. "The brain is particularly good at recognising patterns."

The kind of control room that Reason envisages would look very different to the banks of dials and buttons common today. Out would go the large numbers of warning lights and digital readouts, for example. They would be replaced by, say, a screen display that showed the relative status of sectors of the plant as a bar diagram or as the segments of a pie diagram. The operators would "see" what was happening without having to make calculations.

Interest in studying how people make

mistakes has been increasing since the mid-1970s. There are many reasons for this, but one of the most important is the development of artificial intelligence (AI). Another is the sight of such disasters as Flixborough, Bhopal and the Scilly Isles helicopter crash.

AI provides a way of modelling thought processes. The study of thought is known as cognitive psychology and it has led to Reason's new ideas about human error. The view that people can be considered as components comes from behaviourism, which says that all human action is the result of conditioning. The trouble with the behaviourist approach to safety, says Reason, is that it gives a false sense of security. It relies heavily on the judgment of the systems designer, and may lead plant managers to believe that every safety

precaution has been taken. "It's a little like an MoT—which does not adequately assess the safety of a car, but which leaves the driver feeling reassured."

A behaviourist analysis gives "nuclear engineers and management what they want—numbers" says Reason. But he claims that these numbers are "presented in a form which is intended to be passed on to a second and third generation of analysts. It is doubtful whether such 'cook-book' procedures can sum up 30 years of experience."

Reason says: "There are insufficient data to provide reliable estimates of operator performance within the context of controlling nuclear power plants." In the past, this lack of data was met by borrowing from the experience of better understood processes. "But it is now known that human performance is very sensitive to the specifics of a situation." □

## Dissolution of nuclear waste

BRITAIN'S electricity industry is to harness water-treatment technology to dispose of intermediate nuclear waste. The Central Electricity Generating Board is spending between £1 million and £2 million on a demonstration plant at its Magnox power station at Dungeness, in Kent.

The board is faced with accumulating quantities of intermediate waste, chiefly in the form of metal stripped from the assemblies that contain nuclear fuel. This material is currently stored in large concrete vaults at power stations.

Originally, the board planned to store this waste on site, eventually dealing with it as part of the decommissioning process once the nuclear station ends its operational life. But, because there is more metallic waste than expected, and because of controversy about future ways of disposing this waste, the board is developing a different waste management strategy.

During the past few years the board has researched such options as encapsulation, incineration and water treatment. The last option looks the most promising.

In the water treatment method, waste is transferred hydraulically to a reaction vessel containing water. Carbon dioxide is added to dissolve the Magnox waste. Then the effluent is passed through sand and a fine filter, which removes undissolved particles of radioactive waste. Following both sand and fine filtration, the effluent is pumped into collection tanks. If the effluent is within prescribed limits for radioactivity, it is discharged with the excess cooling water. If the liquor remains too radioactive, the effluent is recirculated through an ion-exchange column.

Although the discharge of this effluent with cooling water will increase the amount of radioactive water released by one or two curies a year, the board says it

will not add significantly to existing discharges. All the coastal Magnox power stations are authorised to release about 200 curies of waste per year, but normally discharges are about 40 to 50 curies annually.

One of the attractions to the board of this method is that it requires very little supervision, compared with other options. Although the method does not dispose of intermediate waste completely, it reduces the size of the problem. Typically, 170 cubic metres of waste from a Magnox station is reduced to 5 cubic metres after treatment.

If the plant works as planned, the board intends to build similar facilities at all its Magnox power stations. The one possible exception is the Trawsfynydd station, which discharges into a lake. The limits for radioactivity are more stringent here, and the plant may not be able to achieve them. □

# Geometers unify their ideas of space

How could we know if the space in which we live is curved, not flat; and why is a coffee cup like a doughnut but not a tennis ball? Mathematicians have found that these questions are not as unrelated as they had thought, and that the answers open up new areas of research

David Epstein

## MATHEMATICS COUNTS



ONE OF the most remarkable developments in mathematics over the past few years has been the way that different areas of the subject have come together. When I was a graduate student 25 years ago, mathematics was a vast expanding field, splintering into more and more isolated areas of study. Now the subject has grown even vaster, but, at the same time, unexpected connections are emerging between apparently distinct topics. For example, the three areas of

topology, geometry and differential geometry have come together in an explosion of activity in the study of two and three dimensions.

Let me begin with differential geometry. This is the study of "metrical properties"—quantities such as the distance between points, surface area, volume—that we can measure with instruments. So how might a differential geometer determine, for instance, that the surface of a round plastic ball is not flat? He or she could proceed as follows. Take a sharp knife and cut a cap from the ball. Then cut a thin strip around the circumference and also cut a diameter from the cap (Figure 1a and b). Take the diameter and circumference and press them so that they lie flat in a plane. As Figure 1c shows, the diameter now protrudes. Suppose that the length of the diameter is  $d$ . Then the length  $e$  of the protruding piece of diameter turns out to be approximately a constant times the cube of the diameter,  $d^3$ —an approximation that becomes better and better as the spherical cap becomes smaller and smaller. This phenomenon was first investigated systematically by the mathematician Karl Friedrich Gauss (1777-1855) and the constant I mentioned is known as the "Gaussian curvature". The differential geometer knows that the surface of the ball is not flat because its Gaussian curvature is not zero.

For convenience, I will invent the term "Gaussian experiment" to describe the process illustrated in Figure 1. But what does this experiment mean? The first thing to notice is that the experiment could, in principle, be performed on an arbitrarily small portion of the ball's surface. In other words, we are looking at a *local* metric property. Secondly, the experiment requires measuring instruments: a compass to mark out the cap, and a ruler to measure the relevant lengths. Thirdly, the measurements could be done, in principle, by a two-dimensional creature living in the surface, unable to detect or measure anything not on the surface.

The experiment in Figure 1 did in fact use the properties of

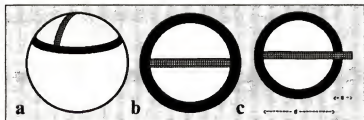


Figure 1 Cut strips from a ball as shown in (a) and (b), flatten them (c), and the diameter  $d$  will protrude by an amount  $e$

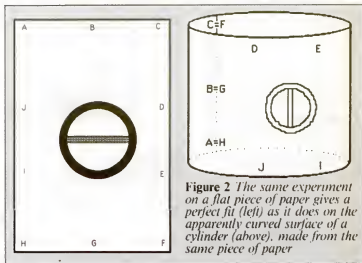


Figure 2 The same experiment on a flat piece of paper gives a perfect fit (left) as it does on the apparently curved surface of a cylinder (above), made from the same piece of paper

the surrounding space, for example in pressing the cut-out flat, but this was a matter of convenience, not of necessity. So how would an intelligent ant, living on the surface, carry out the Gaussian experiment, and measure the curvature? First, it would mark a point to serve as the central point of reference for the experiment. Then, it would pace off a distance  $d/2$  in every direction from this point, so as to draw a circle with that centre, with radius half of the diameter  $d$ . Then, it would count ant steps around the circumference of the circle (or preferably use more precise measuring methods!) to measure the length of the circumference. It would estimate the curvature by comparing  $\pi d$ , the length of the circumference of a Euclidean circle on a flat surface, with the measured length.

Now, suppose we perform the Gaussian experiment on a flat piece of paper (Figure 2). It gives a perfect fit, so the curvature is zero: a flat piece of paper is flat. More surprisingly, as Figure 2 also shows, the "curved" surface of a cylinder is also flat! This sounds all wrong. How can a curved surface be flat? The confusion is a consequence of the use of two distinct meanings of the word "flat". The first is an everyday meaning—a flat table or floor, for example. The second meaning is the technical mathematical statement that the Gaussian curvature is zero: performing the Gaussian experiment gives a diameter that fits perfectly into the circum-

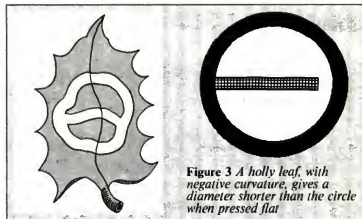


Figure 3 A holly leaf, with negative curvature, gives a diameter shorter than the circle when pressed flat

ference when both are pressed onto a flat table. The cylinder can be formed from a flat piece of paper by gluing the two edges together—that is why the Gaussian experiment gives a perfect fit. A two-dimensional worm living in the surface of a cylinder and performing the appropriate measurements would decide that its space was flat, even though it could crawl on the surface, traveling in what to the worm would be a straight line, and return to its starting point!



Figure 4 The formula  $\pi r^2$  gives too small an area for this circle

The ball of Figure 1 has positive curvature and a piece of paper has zero curvature. What forms have negative curvature? Some leaves do—the holly leaf, for instance. To see this, cut out a small round disk about the size of a 10p piece from a holly leaf, and from this disk cut a circumference and a diameter. Then press these two pieces of leaf flat, and you will find that instead of the diameter protruding a little, there is a gap—the diameter is not long enough (Figure 3). A two-dimensional worm living in the leaf, and expecting a flat leaf, will be agreeably surprised by the amount of nourishment available within a given distance from its starting point; the area of the circle is greater than it is for a flat leaf of the same diameter.

The surface of a cooling tower provides another example of negative curvature (Figure 4). The practical effect of negative curvature can be illustrated by imagining that a contractor is required to paint a circular disk of radius 10 metres on the side of the cooling tower with luminous paint, to warn off low-flying aircraft. If, when he orders his paint, he uses the formula he has learnt at school for the area of a circle— $\pi r^2$ , where  $r$  is the radius—he will run short of paint, for the real area will be greater.

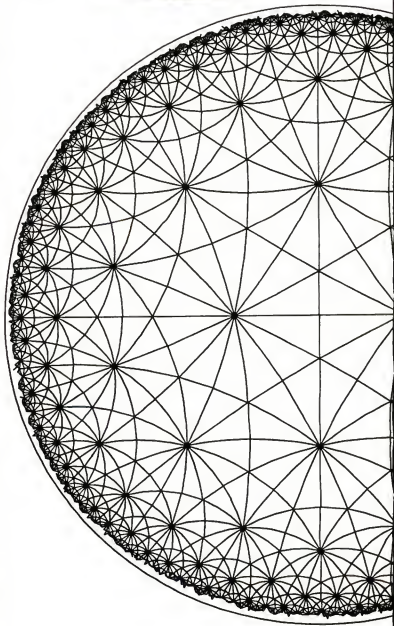
A surface of constant curvature is one for which the Gaussian experiment gives the same result, no matter which portion of the surface is used. The surface of a ball has constant *positive* curvature; an egg, in contrast, has a curvature that is positive everywhere, but not constant. The most important surface of constant negative curvature, is known as the hyperbolic plane. Unfortunately, this surface cannot be put into the ordinary three-dimensional space in which we live, without gross distortion. This is analogous to the fact that the surface of the Earth cannot be mapped without distortion on the flat pages of an atlas. In the case of the Earth, we can make an accurate map with the aid of a globe, using three dimensions rather than two. But even this cannot be done for the hyperbolic plane.

To understand the hyperbolic plane we are obliged to use a map that distorts distances. Geographers use different types of maps of the Earth's surface, depending on which particular feature they wish to emphasise. There are maps in atlases which describe angles accurately—the familiar Mercator projection is an example—and others that describe areas accurately. But because the Earth's surface has a non-zero curvature, no maps on a flat piece of paper can describe *distances* accurately, although if distances are small and the scale is large, inaccuracies can normally be ignored. In the same way, there are different types of maps of the hyperbolic plane, all of which distort distance.

One of these is called the Poincaré model of the hyperbolic plane, though it was discovered by Bernhard Riemann (1826-1866) rather than Henri Poincaré (1854-1912). (Mathematicians are not fussy about historical accuracy.) The famous picture by the artist Maurits Escher, reproduced in Figure 5, shows an infinite pattern of angels and devils in the hyperbolic plane. Each angel drawn is the same size as each



Circle Limit IV, by Maurits Escher, Print/Condon Art



## The curvature of the Universe

As far as our own Universe is concerned, experiments indicate that it is reasonably flat, except for local curvature due to gravitation. Experimental data are not at present accurate enough to distinguish our Universe from a space that is flat (ignoring small local variations). If the Universe really is flat, experimental data will never be accurate enough. But if the Universe is curved, astronomers might be able to determine this in the next few years with the Space Telescope now being planned. In the meantime, cosmologists have proposed various models with different types of curvature, but, in the absence of adequate experimental data, these are regarded as speculative.

To measure the curvature of the Universe, one does not need to be some extra-cosmological intelligence, observing the curvature from "outside". We can measure the curvature, by doing experiments from inside the Universe. However, limitations of measuring methods mean that, in practice, any equivalent of the Gaussian experiment proving non-zero curvature of the Universe would have to have a diameter of many thousands of light years. □

other angel, and each devil is the same size as each other devil. However, because the map distorts distances, the angels and devils on the edge of the map appear smaller than those in the middle of the picture. In much the same way, an inexperienced geographer could come to the mistaken conclusion

that Greenland is bigger than Australia, by looking at almost any map of the Earth's surface.

Figure 5 also shows another regular pattern in the hyperbolic plane, with all triangles of the same (hyperbolic) size. Notice that over small distances, it resembles Euclidean (flat) geometry. The triangles look as though they are Euclidean triangles. Over larger distances, the distinction between Euclidean geometry and hyperbolic geometry becomes apparent, however, when straight lines in the hyperbolic plane have to be drawn as arcs of circles. In a similar way, it was possible in ancient times to believe in a flat Earth.

The discovery of the hyperbolic plane in the 19th century by János Bolyai (1802-1860), Gauss and Nikolai Lobachevsky (1792-1856), had profound implications for mathematics, for philosophy, for science and for man's view of the Universe. It ended the attempt, begun 2500 years earlier, to prove Euclid's "parallel postulate". The idea of the Greeks was to state a number of so-called axioms for geometry, such as "given any pair of points, there is a unique line containing them both." The exact nature of a "line" or a "point" is irrelevant—the only requirement is that these objects, whatever they are, satisfy the

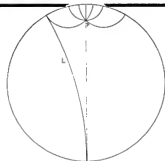


Figure 6 Lines in the hyperbolic plane can be diameters or circular arcs perpendicular to the boundary of the disc

stated axioms. The parallel postulate is the statement: "Given a line and a point not lying on that line, there is exactly one new line through the point which does not meet the original line." For 25 centuries mathematicians puzzled over whether the parallel postulate could be proved starting from the other axioms of Euclidean geometry. Very many fallacious "proofs" appeared over the years. But in the hyperbolic plane, all the axioms of

Euclidean geometry, except for the parallel postulate, are satisfied; the parallel postulate, on the other hand, is definitely false for the hyperbolic plane. It follows that the parallel postulate cannot be deduced from the other axioms.

To understand this, we have to say exactly what the "lines" and "points" of the hyperbolic plane are. A "point" is just a usual point, like P in Figure 6. A "line" is either a diameter or a circular arc, perpendicular to the boundary of the disk drawn in Figure 6. Such a diameter or circular arc is in fact the shortest path between two points using hyperbolic distance—remember that the distance is distorted in the map. In the same way, on the Earth's surface, the shortest route from London to San Francisco is the Polar route, while a straight line drawn with a ruler on almost any map in an atlas showing both London and San Francisco will pass through the East Coast of the United States (Figure 7).

Figure 6 shows how, given a point P in the hyperbolic plane, and a line L not containing P, there are infinitely many lines through P that are "parallel" to L—that is, they do not meet L. In Figure 6 the lines drawn are entire lines, with no part omitted. They extend infinitely far in each direction, but the distance seems finite because there is an infinite amount of distortion in the map.

During the 18th century the philosopher Immanuel Kant had put forward the theory that both the parallel postulate and Newton's laws were known to be true for "synthetic *a priori*" reasons. During the early 19th century, all cultured people regarded this as self-evident. The discovery of the hyperbolic plane demolished half of this theory, and the arrival of relativity and the quantum theory demolished the other half. Psychologically, the result was to dent confidence in intuition. In mathematics, the effect was to reinforce the need, already felt, for improved standards of rigour in setting up the foundations of mathematics.

Having given some description of differential geometry and the hyperbolic plane, I would now like to say something about topology, popularly known as "rubber-sheet geometry". It is the study of those properties of space (think of an object when I use the word "space") that are preserved when the space is deformed elastically. Imagine the space to be extremely stretchable, but not at all sticky. Given a solid ring made of plasticine, for example, you can squash it in your hand into a ball, because the plasticine sticks to itself. This operation is *not* allowed in topology. In contrast, to a topologist, a coffee cup is "the same" as a solid ring. To see this, imagine the coffee cup to be made of very, very, elastic material. First, we squash away the cup part, leaving only the handle attached to a flat elastic disk (which used to be the bottom of the cup). Then we squash the disk into the handle, and we are left only with the handle, which is a solid ring.

In topology, unlike differential geometry, metrical properties are irrelevant. Topological properties can usually be determined without instruments—for example by counting. The first and most important example of a topological property is the so-called Euler number. Suppose you draw triangles on the surface of a solid body, which fit together neatly

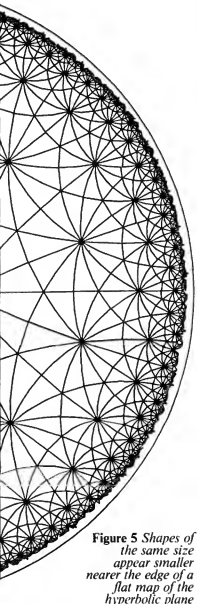


Figure 5 Shapes of the same size appear smaller nearer the edge of a flat map of the hyperbolic plane

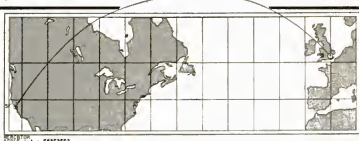


Figure 7 The shortest routes are not always straight lines

along the edges. The Euler number is then the number of vertices minus the number of edges plus the number of triangles. This number is the same even if you draw the triangles in entirely different ways. One way could consist of only a few edges, another could consist of millions of edges, but the answer would always be the same. From this it follows that an elastic deformation, of the type I described above, will not change the Euler number. The number is always 2 for a ball, 0 for a solid ring, and 0 for a coffee cup. This proves that a coffee cup is topologically the same as a ring, but not the same as a ball.

What is the connection between differential geometry and topology? In topology we are free to stretch a space and to change its metrical properties. A remarkable theorem due to Riemann and David Hilbert (1862-1943), is that any surface is (topologically) equivalent to a surface of constant curvature. To illustrate this theorem, consider a balloon. Most balloons are not perfectly round. They have a positive curvature but the curvature is not constant. But, a balloon can always be deformed to be perfectly round (Figure 8).

The surface of a doughnut (called a "torus" by mathematicians) in three dimensions has a curvature that varies as Figure 9 shows. However, it is possible to make this surface flat (zero curvature all over) in four dimensions, though not in three dimensions. To see how to make a flat torus, we have to use a flat piece of paper. We start with the rectangular piece of paper ABCDEFGHIJ, and glue ABC to HGF, obtaining a cylinder with circular ends (Figure 2). We then glue the circular ends to each other (Figure 10). Unfortunately, the paper has to crinkle in the last gluing, because we are obliged to work in only three dimensions.

Another way of expressing the result established by Riemann and Hilbert, is that every surface is topologically equivalent to a surface with a geometric structure. A space is said to have a "geometric structure" if local experiments are unable to distinguish between different points of the space. In two dimensions there are three types of geometric structure: spherical, with constant positive curvature; flat, with zero curvature; and hyperbolic, with constant negative curvature. For curves there is only one geometry—that of the straight line. A one-dimensional insect living on the circumference of a circle can do large-scale experiments to show that it lives in a circle, and not in a line, but for all local experiments the circle and the line are indistinguishable.

An important aim of modern research in topology is to prove the conjecture, due to William Thurston, of Princeton University, that a geometric structure can be imposed on three-dimensional spaces provided they satisfy some obvious necessary conditions. Thurston's conjecture has been, and seems likely to continue to be, one of the main engines driving modern research in low-dim-

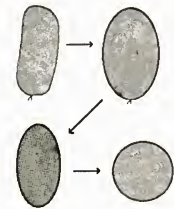


Figure 8 Balloons are not usually perfectly round but they can always be deformed and made perfectly round

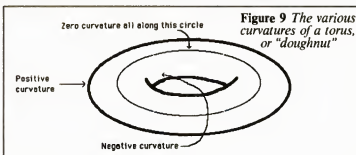


Figure 9 The various curvatures of a torus, or "doughnut"

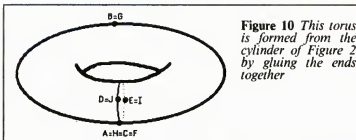


Figure 10 This torus is formed from the cylinder of Figure 2 by gluing the ends together



Figure 11 A knot has no metrical properties, but a geometric structure can be imposed on all points in space not in the knot

ensional topology. Its investigation is continually throwing up new and intriguing problems, providing a constant stream of PhD theses and research papers. In three dimensions there are eight geometric structures. The most commonly occurring type turns out to have constant negative curvature—it is hyperbolic. (In four dimensions, there are an infinite number of geometric structures. These have been investigated by Rick Filippiewicz, one of my former students.)

There are some remarkable examples that illustrate Thurston's conjecture and help mathematicians to believe in its truth. Thurston has in fact proved the truth of the conjecture for the "complement" of a knot in ordinary Euclidean three-dimensional space—that is, all the points of the space except those in the knot. The complement of a figure-eight knot has a geometric structure obtained by gluing together the faces of two regular hyperbolic tetrahedra. Unfortunately, this fact is difficult to demonstrate in a short article. Visitors to the Mathematics Institute at the University of Warwick may inspect a model, made by two of my students and my wife, which demonstrates the point.

The implications, even of the restricted versions of Thurston's conjecture that are known to be true, are considerable. For example, a knot such as in Figure 11, is a topological object, with no particular metrical properties. It is "flabby": one can deform it, and no essential change is made. But when a geometric structure is imposed on the complement of the knot, everything rigidifies. As an example, it makes sense to talk of the "volume" of the knot complement. This volume is not measured using the usual Euclidean volume normally associated with three-dimensional Euclidean (flat) space, but using the natural volume associated with three-dimensional hyperbolic space. Indeed, the hyperbolic volume by itself seems to be one of the most important topological invariants of a three-dimensional space. Unlike classical invariants (the Euler number, for example) it is a real number and not an integer. To a topologist, this insight, which has come from the marriage of geometry and topology, is in itself an exciting new phenomenon. □

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Bahrain's causeway is a vital link for the Gulf. But civil engineering on this scale inevitably disrupts fragile marine environments



Christine Osborne/Node East Pictures

## Bridge over fragile waters

The causeway between Saudi Arabia and Bahrain is one of the biggest feats of offshore engineering in the world. It also provided an opportunity for a unique study of the marine environment of the Gulf. The results are not reassuring

David Vousden and Andrew Price

**I**N SUMMER 1982, civil engineers won a contract to build one of the largest offshore constructions in the world. It is a roadway from Saudi Arabia across 25 kilometres of sea to the island state of Bahrain. The causeway, which is now nearing completion, consists of five bridges linked by solid embankments. It carries two parallel roads from Jasrah on the northwest coast of Bahrain, across Umm Na'san island, over the Gulf of Bahrain to join the Saudi coastline at Al Aziziyah. The largest of the bridges weighs 1200 tonnes, and passes 28.5 metres above the water. The structure will be able to carry 3000 vehicles per hour. Halfway between Umm Na'san and Al Aziziyah, an artificial island will house coastguards, customs and immigration offices.

A project of this size would have a profound effect on the environment anywhere in the world. Marine life in the shallow and almost landlocked Arabian (or Persian) Gulf is especially vulnerable. The governments concerned agreed on the causeway's final design, from a choice of three, as the one least likely to damage the marine environment.

Environmentalists were particularly concerned about the heavy dredging and coastal reclamation that the project would involve. At least half of the causeway's span consists of embankments of dredged rocks and fine mud spoil. Not only does the act of dredging and infilling destroy marine life directly, it can have equally harmful secondary effects. Clear waters become thickly loaded with fine suspended sediment, reducing the amount of light that gets through, and therefore the photosynthetic activity of seagrass beds and symbiotic coral algae. Currents can carry dense clouds of sediment to settle out again in less turbulent waters, often many kilometres away. Building large barriers of mud and rocks across

previously open channels can permanently alter patterns of water circulation, and change the water's temperature, salinity and other characteristics beyond the levels that native species can tolerate.

All this could be particularly significant in the waters between Bahrain and Saudi Arabia, which are, on average, only five metres deep. Also, artificial obstructions can change the migratory habits of shrimps and fish.

With these questions in mind, the Regional Organisation for the Protection of the Marine Environment (the Gulf area's marine conservation organisation) arranged to cooperate with Bahrain's Directorate of Environmental Affairs to carry out an ecological study of the coasts of Bahrain. It would concentrate on the possible effects of building the causeway. A team from the Tropical Marine Research Unit at the University of York carried out the study through the International Union for Conservation of Nature and Natural Resources and the UN Environmental Programme.

The survey consisted of three visits to Bahrain in 1983, each of about a month. We sampled the flora and fauna, and studied oceanographic features such as the water temperature, salinity, turbidity and concentrations of chlorophyll and zooplankton at six coastal and six offshore sites. The idea was to assess the state of marine life in this part of the Gulf, and to detect any changes that took place during this period as work began in earnest on the causeway. We paid particular attention to the area around the causeway, and to the commercially important shrimp fisheries. We made extra observations at a number of other sites, such as the seldom-visited Hawar archipelago to the south, and the coral reefs of the east coast of Bahrain.

Many of these places deserve the term critical habitats—they are identifiable areas of special concern in conservation. They may be vital to the survival of a species at some stage in its life cycle, or to the survival of a community. Of particular concern around Bahrain are seagrass beds, coral reefs, mangroves, and mudflats (see Box). Seagrass beds are highly productive and are important feeding grounds for green turtles (*Chelonia mydas*) and dugong or sea cows (*Dugong dugon*), a settling substrate for animals such as juvenile pearl oysters (*Pinctada* spp.) and a nursery and feeding ground for shrimps (*Penaeus semiculatus*).

Coral reefs, as well as being outstandingly beautiful, support local fisheries and rich marine life in general. Mangroves and mudflats are also highly productive, and sustain juvenile shrimp and fish species, as well as large populations of birds and other marine organisms.

We found large seasonal differences in water temperatures. At coastal sites, the temperature ranges from 14–35°C. Offshore it ranged from 13–31°C. This range is greater than at comparable latitudes elsewhere because the Gulf is relatively sheltered and almost landlocked. In particular, its shallow waters have a small thermal capacity. Its water temperatures track air temperatures more closely than open oceans would. Extremes in temperature, both high and low, undoubtedly limit the number of species that can survive in the Gulf.

The water is also very salty, about 10 per cent more so at the west coast of Bahrain than at the east coast. This is partly because of Bahrain's geographical position with only a shallow narrow stretch of water separating the island from the Arabian mainland; but also important is the complex circulation of water in the Gulf, and the effect of a large, almost stationary and highly saline body of water called Dawhat Salwah, to the southwest. The further south we took readings, the more saline the water became.

The combined effect of fluctuating extremes in temperature with very high salinities is to produce an environment that, even without the effects of the causeway, is naturally highly stressful to the organisms living in it. Many plants and animals are already living at, or even beyond, their normal range of tolerance. For example, reef-building corals are generally considered to tolerate temperatures down to 18°C, yet well-developed coral reefs do occur in the Gulf. Similarly, echinoderms survive in lagoons with a salinity of 60 parts per thousand, which may be a new record for this group of animals in the wild. Consequently, any reduction in water circulation, especially in shallow waters near the coast, may further increase salinity and temperature ranges to levels that many of the plants and animals cannot tolerate.

In the immediate vicinity of the causeway between Umm Na'san and the main island of Bahrain, we found the

water nine parts per thousand more saline in the now partly enclosed bay on the south side of the road than just to the north, less than 100 metres away. However, the design of the causeway includes plans to open up this solid section of road with at least one bridge section, and this will help to return salinity levels within the bay back to normal. Certainly, any alteration in salinity around the causeway appears to be quite local.

Of greater concern are the more obvious physical impacts of dredging and reclamation. The water became more turbid the closer we moved to the construction work. Long plumes of sediment stretched downstream from the construction areas. Just to the north of the causeway, during dives we found a layer of very fine silt and mud 20 centimetres thick, with a complete absence of surface flora and fauna, but a high abundance of infaunal polychaete worms dominated by *Ceratonereis*. Below the silt was a once-healthy seagrass bed, now almost completely dead. This may well have been part of a large nursery within the bay area, as large numbers of juvenile shrimps and fish thrived in the nearby intertidal flats. These flats also support a rich fauna, including crabs and molluscs. Invertebrates such as these depend directly or indirectly on the rich growth of benthic diatoms and blue-green algae. At the two sites south of the causeway on the west coast of Bahrain, there was no clear evidence of damage.

### Classic symptoms of stress

We chose the coastal and offshore sites on the east side of Bahrain for their relative isolation, far removed from any likely effects of building the causeway. The coastal sites, particularly the one to the north, had a rich invertebrate and vertebrate fauna. Blue-greens and other larger forms of algae account for most of the productivity. The coastal area is also an important nursery for shrimps and fish. For example, hauling a seine net over 80 metres of flooded intertidal muddy sand produced a mixed catch of more than 1200 juvenile and adult fish as well as more than 600 juvenile shrimps.

A different picture emerged at the offshore sites on the east coast. We expected to find a relatively unspoiled area, but instead the water was turbid. Visual inspections during our dives and from helicopters supported these observations. Even on calm days, visibility underwater went down to 60 centimetres, and a layer of fine silt covered the seabed at the offshore sites. Impact on the east coast extended to the coral reefs, several of which displayed the classic symptoms of sedimentary stress, with horizontal faces showing bleached skeletons devoid of polyps. This was particularly clear on the massive coral such as *Platygyra*, where the round coral head looked like a monk's tonsured haircut with the top bleached

## Gulf's critical marine habitats in danger

Coral reefs are one of the most productive ecosystems in the oceans. They also have the greatest diversity of species. In shallow tropical waters, reefs are important to local fisheries. Although few fish eat the coral itself, reefs provide food and shelter for numerous invertebrates.

Several hundred patch or platform reefs are scattered around the Gulf, particularly along its western and southern shores. Flourishing reefs also surround offshore coral islands. These islands themselves provide nesting sites for several species of terns, and green and hawksbill turtles.

Coastal development damages coral reefs by making the water more turbid. This aggravates the effects of high temperature and salinity, and impedes photosynthesis. Sediment also smothers coral directly.

In some places, channels are being

blasted through reefs to allow ships to pass. Ships' anchors can also do damage. Another danger is oil: frequent small spills may do more harm than one large spill.

Intertidal flats and mangroves are often thought of as wasteland. Yet such areas are exceptionally productive. For example, a luxuriant film of benthic algae and diatoms on the surface of intertidal flats provides a direct and indirect source of food for fish.

Similarly, mangroves provide a first link in the food chain when their leaves decompose in the water and shrimps and other invertebrates feed on them. Mangroves can also provide wood, and raw materials to make tannin, rayon, glues and dyes.

Mangroves stabilise the environment by binding soft muds and sediments which would otherwise tend to erode. Perhaps most significantly, they function as a nur-

series area for young fish and shellfish.

In many parts of the Gulf, infilling for reclamation is systematically destroying these refuges. Yet ample space is available for construction further inland.

Seagrass beds look like underwater meadows. They produce food for marine animals. Turtles and dugong feed directly on the plants, as do some fish.

Many other animals, such as commercial shrimp and pearl oysters, also live among seagrass. The oysters seem to rely on seagrass for larval attachment and growth. Around Bahrain and other coastal waters of the Gulf, seagrass beds play a key role in sustaining of local fisheries.

These beds appear to have been reduced over recent years as a result of dredging, infilling and other coastal development. Their mapping is essential. □



*Dredging produces silt (right) which drifts downstream, damaging the habitats of endangered animals such as the hawksbill turtle*



*Andrew Price*

white! We also saw dead and dying branches of *Acropora*, covered in sea urchins or turned green by colonies of epiphytic algae. From the air, we could see many dredgers at work, surrounded by spoil tips and with white streamers of sediment pouring away on the current.

Elswhere, large tracts of coastline and subtidal seas are being filled with this reclaimed material. For example, the mangroves associated with mudflats within Tubli Bay on the east coast have been filled in and reduced to just a few small stands; the largest little more than 400 square metres. These are the last remaining survivors of what was once an extensive system of mangroves.

Other extensive mudflats exist along most of the northern coast of the main island, but no one has yet surveyed them for their scientific or economic importance. They are already scheduled for infilling in the immediate future. This is often the fate of these highly productive intertidal flats throughout the world, mainly because of the ease with which they can be reclaimed from the sea and the fact that people often regard them as "worthless swamps". It is these very areas, which need protection and conservation, which coastal development schemes put at risk.

The environmental problems that Bahrain faces reflect the even greater problems that threaten marine life and resources throughout the Gulf. Massive coastal development and the resulting heavy pollution, coupled with the natural stresses already imposed on the indigenous flora and fauna, are a serious problem. Best known, however, is the damage that comes with the extraction and processing of crude oil. This has inevitably degraded the marine coastal and offshore environment. The Gulf oil spill of 1983 highlighted the problem.

Shortly after the spill, large numbers of dead animals were washed up on beaches. The victims included fish, turtles, seashells, dolphins and dugong. Many of the dead animals were recorded on Saudi Arabian beaches, while very few turned up in Bahrain. We do not yet know whether the oil spill directly caused these deaths. Autopsies on fish from certain areas of the Gulf showed them to have tainted flesh, but this situation did not last for long.

The oil seems to have most effect on offshore islands in the Gulf. Scientists visiting the area say that thousands of breeding terns have been fouled by the oil, as have nesting green and hawksbill turtles. Below water, coral itself, along with associated life-forms, may also have suffered, with the coral producing copious quantities of mucus as a reaction.

Given the number of oil rigs in the Gulf, and the

continuous movement of tankers up and down these waters, spills such as this are an all-too-constant threat. The fighting in the northern part of the Gulf, and especially attacks on shipping, has increased this likelihood even more.

Other threats to the marine environment of the Gulf are sewage effluent from coastal towns and villages, causing nutrient enrichment and possible eutrophication; effluents from refineries which cause heavy metals to concentrate in sediments and certain organisms; and other effluents, for example from fertiliser and desalination plants. However, although these industrial polluters have significant effects in parts of the Gulf, the damage they do is less severe than the loss of habitat caused by dredging and coastal infilling.

The Gulf is undoubtedly a marine environment of great value, both economically and scientifically. Pearling, fishing and commercial shrimping together provide millions of dollars of revenue to the countries on its shores. Throughout history, populations living around this body of water have relied heavily on these marine harvests.

The Gulf also contains species of special conservation significance. Some of these, for example green and hawksbill turtles, are threatened worldwide. Others, such as dugong, are vulnerable. We simply do not know the status of many others, either locally or worldwide. Particularly interesting are endemic species—plants and animals that are believed to be unique to a particular region. In one group of animals (echinoderms) present in the Gulf, 12 per cent of the species appear to be endemic. Among birds, the Socotra cormorant is also endemic. Breeding colonies are found in certain bays and islands in the Gulf. However, for the most part, scientists know little about the Gulf endemics, largely because of the incompleteness of sampling and taxonomic knowledge.

We have already mentioned the stressful nature of the Gulf's environment. For example, the area's coral reefs are of particular interest to scientists because they manage to exist near the limit of their tolerance in an environment of high salinities and wide variations in temperature. They also provide ecologists with an opportunity to study an otherwise complex community in a relatively simple form. Local coral reefs, of course, also provide an enormous recreational attraction, reason enough for conserving them.

Observations to date show that so far, building the causeway has probably had only a localised effect on the marine environment on the west coast of Bahrain. The efforts of the Bahraini and Saudi authorities, together with the construction company Bandr-Ballast, to limit environmental damage, have so far been gratifyingly successful. However, comparative studies on the east coast of Bahrain show how a variety of other impacts are damaging this much more productive area. Infilling and dredging do particular damage.

In fact, throughout the Gulf, the loss of marine habitats as a result of these activities is now serious. It is even possible that species that would be new to science are becoming extinct before they are discovered. The same thing is happening in tropical rainforests. Fortunately, the governments of the Gulf states are becoming more aware about environmental damage. Organisations such as the Regional Organisation for the Protection of the Marine Environment continue to make studies and now urge the need to regulate the exploitation of critical marine habitats, to control effluents discharged into the sea, and to adopt environmental standards for the marine and coastal environment.

Most important, more and more people realise that the Gulf, as an almost enclosed waterway with resources that cross national boundaries, needs to be managed and conserved by a joint venture between all the Gulf countries. □

David Vousden and Andrew Price, of the Tropical Marine Research Unit, University of York, carried out this study for the Regional Organisation for the Protection of the Marine Environment, Kuwait. David Vousden now works at the Directorate of Environmental Protection in Bahrain. Dr Andrew Price is a senior marine ecologist/research fellow at York.

## **If we need an effective county planning authority here...**



MOLE VALLEY, SURREY

The government accepts that the shires should retain elected councils, sensitive to their needs, to prepare and implement a planning strategy on a county-wide basis.

London, with its 7 million people and infinitely more complex development, transport and environmental considerations, apparently requires no such body. Hence the decision to abolish the GLC.

Instead of one strategic plan for London there will be 33.

Instead of a London-wide authority with powers and resources to influence the future development of the capital, the 33 separate Borough authorities each will have a remit to look only after its own local area.

## **don't we also need it here?**



Instead of an open inquiry into one plan, the key planning policies for London will be decided by the Secretary of State for the Environment advised by a "London Planning Commission," a quango that he will appoint. There will be no London-wide inquiry into these policies.

The claim that all planning responsibility will devolve to the Boroughs is a sham. The Secretary of State for the Environment will become London's strategic planning authority and Londoners themselves will have a far less effective voice in the major decisions affecting their city.

Why should Londoners be treated differently?

For further information call 01-633 2220

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# REVIEW

## Fighting the good fight

"I THINK anyone who reads this book will realise that the animal rights movement is here to stay" was the message from Peter Singer at the London press launch of *In Defence of Animals*.

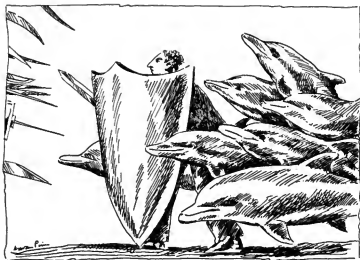
Singer, Professor of Philosophy at Monash University, Australia, has edited a collection of 15 short essays by campaigners involved in all aspects of the animal rights movement. The contributors range from philosophers, through law reformers, to activists, providing an insight into their vastly varied standpoints and motivations.

The book is divided into three sections—the ideas, the problems and the strategies. It does not, however, provide detailed information on specific issues, such as animal experimentation, farm animals or zoos. Although these topics are dealt with in the "problems" section, better sources are available. It is, more importantly, a book which might enable us to understand animal rights as a societal issue.

As Singer points out, the issue will not go away; its moral foundations are too strong. But many of us share his deep concern about the direction in which the

**In Defence of Animals**  
edited by Peter Singer, Basil Blackwell, pp 224, £15 hbk, £4.95 pbk

Judith Hampson



movement might go. Singer condemns recent escalations into violence which undermine the philosophical concepts upon which the notion of animal rights is based. Such actions deepen polarisations, leaving animals the victims, as well as people.

The contributors to this book share Singer's view, though perhaps not all of them share his insight into the damage violence can do to their cause. The fight, Singer points out, is about morality and it cannot be won by means which are wrong. Indeed, among the angers and

frustrations expressed by these writers there does appear to be a common unity, an inspiration which is more than a pious hope that justice will triumph in the end.

There are calls for realism: liberationists urging their overzealous supporters not only to accept attainable reforms but also to aim for them. Alex Pacheco, instigator of the Silver Springs monkey trial, warns: "Realising that total abolition of some aspects of animal exploitation may never come, we should not simply demand 'total abolition or nothing at all', as that often ensures that those suffering today will continue to suffer."

Henry Spira, former trades union activist, has successfully "blackmailed" several US companies into ploughing thousands of dollars into research on "alternatives" to animal testing. He urges supporters to "Keep in touch with reality. Dreaming about how great it would be if animal experimentation were totally abolished does nothing to bring that day closer, and it does nothing to help the animals who will suffer tomorrow and every other day we continue to dream." Quite so.

I WAS jolly glad it was the book I'd been asked to review, and not the television programmes. I cannot remember the start of a major television series receiving such a pasting from the critics next morning.

At the time of writing, only the first of the planned 10 programmes had been broadcast. It began with that huge head obscuring the rising Sun, and then he was off, bobbing and weaving while a confusing set of images were projected behind him. Having the advantage of reading the book beforehand, I could at least understand what he was trying to do. Evidently he wished in this first programme to capture attention by introducing all the ideas he planned to develop in later instalments. It was, in fact, a sort of overture containing all the themes, but one that was so cacophonous it threatened to clear the auditorium before the start of the main show.

Publication of the lavishly illustrated book of the series coincided with the first of the broadcasts. It too has 10 chapters. The first, an introduction,

## Missing connections

**The Day the Universe Changed**  
by James Burke, BBC Publications, pp 352, £14.95

Jack Harris

is followed by an account of eight events which "changed the Universe", or at least our perception of it. Burke's eight events are: the promulgation of Greek knowledge from Arabic Spain, the discovery of perspective, the development of the printing press, the derivation of the law of gravity, the industrial revolution, developments in medical statistics, Darwinism and, finally, the discovery of radioactivity leading to the atomic bomb. The final chapter is designed to draw it all together.

It is quite evident that Burke has done his homework; he has an encyclopedic knowledge of the history of science, and is an inspired commentator on the evolution of technology. Each chapter is a self-contained essay arranging facts in an interesting and unusual way so that new truths are revealed. The question arises, do all these small truths add up to a greater

truth? Can we expect a denouement in the last chapter?

Alas no; the more our author attempts to draw the threads together in Chapter 10, the more everything seems to fall apart. We learn that mythology, religion and science all produce cosmologies and, as all are subject to change, each may have equal validity. We are told that there is no absolute reality, no special direction to events. The Universe is what we say it is. When theories change, the Universe changes—the truth is relative. If there is no coherence, no synthesis, does this mean that the whole exercise has been a failure? Perhaps it does, but if there is no ultimate truth, how can one expect to end up other than disappointed if one sets out to try to find it?

In conclusion, I must write a few words about translating a work of art or scholarship from one medium to another, book to

film or vice versa. Throughout his life, E. M. Forster resolutely refused all requests to turn *A Passage to India* into a film—it only became possible after his death. No doubt he felt that the subject of his book—human relations across a cultural divide and what went on in the darkness of a cave—were unsuitable for visual interpretation. On perhaps a slightly lower plane, in my view, the liberal use of images does not assist in conveying Burke's theories and ideas. Of course, if you are charged with producing a 10-part television series then you have no option but to confuse everyone with a superabundance of pictures. But why did he feel it necessary to reproduce so many illustrations in his book—I have counted 300. Was it to keep in with the "coffee table" format of BBC publications? As Burke reminded us, the arrival of the printed word made much ornamentation redundant.

There was a time when a select group of intellectuals (for example, Wheeler, Taylor, Muggidge, Clark, Bronowski) first became savants and scholars and then, in their

As Clive Hollands, Secretary of the Committee for Reform of Animal Experimentation (CRAE) in Britain stresses: "Political action will always be concerned with practical possibilities. Animal welfare must come to terms with this fact. We do animals a disservice when we place our sacred principles regarding rights over achieving some progress in alleviating their suffering."

Not everyone finds it easy to share Hollands's pragmatic approach. Certainly it has done nothing to ingratiate him with the rank and file of the animal rights movement. But, perhaps more to the point, it has achieved some concrete improvements for laboratory animals.

Tactics aside, *In Defence of Animals* makes it clear that there is a moral case to be answered. Animal rights is not about animal welfare, nor is it about compassion. It is about justice. As Professor Tim Regan, elegantly summarising his lengthy philosophical treatise *The Case for Animal Rights* (Routledge and Kegan Paul, 1983), points out: "You don't change unjust institutions by tidying them up."

It is this conviction that leads some activists to break the law. Dexter Cate spent weeks in a Japanese prison awaiting trial for freeing dolphins about to be slaughtered by fishermen on the island of Tatsunoshima. His

story of how that action came about on "the island of the Dragon" is the most moving and beautifully written piece in the book. It also provides a clear insight into the mind of the activist. Cate offers no discussion of whether his action was tactically correct—clearly in one sense it was not, as he was deported from Japan and thus prohibited from continuing the fight. But at the time "that did not seem to be the point. I had witnessed my brothers and sisters of the sea suffering and had had the opportunity to help them. I really had no choice. Was it worth it? Ask the dolphins."

Striking the balance between working for what is attainable and remaining true to the moral ideal is the greatest challenge facing those fighting for the rights of animals today. How they strike it will affect us all. Animal rights is a societal issue; it is arguably less about animals than it is about ourselves.

There is much for everyone to agree or disagree with in this book. It may inspire or enrage the reader; it might well do both. If it can be read with a reasonably open mind, it will enable those involved in the animal rights debate to gain a clearer understanding of the perspectives and motivations of others. This can only lead to better dialogue. If the book serves to foster such dialogue it will have more than served its purpose. □

## The bell tolls for butterflies

Butterflies of Dorset

by Jeremy Thomas and Nigel Webb, *Dorset Natural History & Archaeological Society*, \* pp 128, £7.95 hbk, £5.95 pbk

Ashley Morton

WITH 48 species regularly breeding within its boundaries, Dorset has an abundance and diversity of butterflies, unmatched by any other county. This alone could justify the production of *Butterflies of Dorset*, but this book should be considered in a wider context.

First, it is the best guide to a county faunal or floral group I have seen. Thankfully, distribution maps replaced long lists of localities some time ago, but the 1 square kilometre scale used here produces a map which can actually be used to explore the area. Additionally, Thomas and Webb recommend specific localities where each species may be sought. They also present bar graphs (based on weekly observations over nine years) which give an accurate indication of when the adults are likely to be found—a refreshing change from the "Chiltern Hills, May to July" approach.

Secondly, the authors give accurate information about habitat requirements, behaviour, life history and larval food plants for each species. These should enable most naturalists to locate successfully eggs and larvae. This is important because some species are more easily found as immatures than as adults, and others fly in some habitats but breed only in others. A survey based just on adults could be misleading in terms of both status in the county and areas worth conserving. Although the book is not intended as an identification guide, it also boasts 56 colour photographs of the adult butterflies in their natural habitats. Unfortunately a few of these serve only to reduce the overall standard of production which, for such a small concern, is generally high.

The aspect which confers national importance on this regional study is the careful analysis of the changes in distribution and abundance of Dorset's butterflies revealed by the recording schemes. At least 21 species have declined markedly during the past 30 years, and eight of these species have lost more than two-thirds of their colonies. Other surveys have demonstrated the serious declines of many butterflies in eastern England, but the fact that problems also exist in the Dorset strongholds is a clear warning that

all is not well in the British countryside.

In their discussion of the reasons for these declines, the authors emphasise that a number of species are likely to persist in Dorset only on nature reserves, where their habitats are deliberately maintained. This view is more depressing than it may appear. Successes have outnumbered losses on Dorset's nature reserves, but this is another unusual attribute of that county. Elsewhere butterflies have an appalling history of survival on nature reserves, almost invariably because conservationists have failed to maintain sufficient (or any) suitable breeding habitat. The authors do not discuss the reasons for this difference, but it is not independent of the relationship between the local conservation bodies and entomologists at Furzebrook Research Station.

Thomas and Webb have failed to consider one important aspect of the conservation question. It is not just a question of conserving butterflies, but one of conserving entire communities of invertebrates which, for logistical reasons, are largely ignored by ecologists. In many habitats, butterflies are the most readily censused and representative group of plant-eating invertebrates. It is reasonable to assume that the local extinction of a butterfly species is a conspicuous indicator that many other herbivores (which may have been of vital importance in certain food chains) have probably been lost.

Unfortunately, habitats frequently become unsuitable for butterflies long before there is any noticeable change in the flora, and it is all too clear that the usual ecological assessments based on plant communities, so favoured by conservation bodies, may provide no reliable information about the status of these diverse animal communities at all. There is a strong case for exploring the use of butterfly communities as indicators of the overall richness of some types of habitat. *Butterflies of Dorset* should encourage conservation bodies and naturalists to monitor the status of these insects more effectively. □

\* Available from: DNHAS, Dorset County Museum, High West Street, Dorchester DT1 1XA.



The new print shops were centres for intellectual exchange

middle years, had fame thrust upon them by appearing on television. In a sense Burke has reversed this sequence. He became very well known early in his career, as a presenter on *Tomorrow's World* and *The Burke Special* and as a reporter of the NASA Apollo missions. Later, with the appearance of

*Connections* and the present volume, there are signs that a scholar is attempting to escape from under the weight of all that fame. It would be ironic if he now finds himself hampered in his attempt to convey to the public the fruits of his scholarship, by his image, and by his images. □

AS PROFESSOR at the universities of Keele, Reading and now York, Toronto, Antony Flew has encouraged students of philosophy and logic to develop skills of logic and persuasion with the wit and grace that he shows in this outstanding book.

He surveys his earlier studies on Malthus, Hume, Adam Smith and Marx, and scours with gusto the more recent aberrations of the past decade. As a long-serving vice president of the Rationalist Press, Flew is unlikely to lose composure at failing to render appropriate obeisance towards dogma. He has a deep and compelling regard for Charles Darwin, as is shown in his brief but untraditional account of Darwin's life which begins his text. The quotations throughout are unhackneyed, never repetitious and often memorable. His bibliography is an irresistible invitation.

Not that he is soft over Darwin's failures. When Darwin proposed his laws of variation, he had not the benefit of Mendel's insights, neglected until 18 years after Darwin's death. Flew warns against the proud superiority of hindsight. Darwin was supposed to lack metaphysical and philosophical insight, though he was known to have enjoyed his undergraduate exercises on William Paley's *Evidences of Christianity*. Paul Barrett's transcriptions of Darwin's *Metaphysics & Expressive Notebooks*, incorrectly ascribed to Howard

## Making choices

Darwinian Evolution

by Antony Flew, Paladin, pp 149, £2.50

Sydney Smith



Darwin was not tentative

Gruber on page 63, are now enabling them rightly to take their place with the *Transmutation Notebooks*, and show the extent of Darwin's reading of Hume, Reid and Adam Smith.

1882 was the centenary of Darwin's interment close to Isaac Newton in Westminster Abbey. Like his grandfather, Erasmus, who was a pioneer evolutionist, and like his father and his elder brother, Erasmus Alvey, who were unbelievers, Darwin came to share their views, certainly by the time of his marriage to his devoutly religious wife, Emma. It was the publication of his *Autobiography* in 1958 (not 1968!) by his granddaughter Nora Barlow, that revealed the excisions in the 1887 *Life and Letters*, made no doubt to

comfort his wife.

I can add another change to the text of his letter to Emma, dated 5 July 1844, arranging for publication in the case of sudden death (his health was poor): "I have just finished my sketch of my species theory. If, as I believe, that my theory is true, & if it is accepted by one competent judge it will be a considerable step in science."

The usual text is given by Flew on page 8. Darwin's mood is falsified by a totally alien tentativeness. Perhaps this tampering was undertaken to square with the supposed irresolute vacillation which was believed to have put off publication for 14 years. In fact Darwin worked hard for the whole period to overcome the problem of the origin of divergence, his solution for which dates from November 1854 onwards.

Flew pillories Desmond Morris, author of *The Naked Ape* and Richard Dawkins, author of *The Selfish Gene*, as reductionists and "catchguinea" writers. And he condemns the use of weasel words for opposing hallowed concepts, as the Editor of *Nature* rightly accused the Natural History Museum officials of doing in their newly set up Evolution Gallery. These officials opposed classification

based on descent, for they were palaeontologists by training, seduced by an entomologist (Emil Hennig) to the new faith of cladism. Flew also condemns the adoption of a transitory aberration of Karl Popper, that as Darwin's theory was no more than an hypothesis, it did not meet the truly scientific requirement of verifiability. The question of Malthus's influence on Darwin's "Powers, Checks and Choice" is succeeded by a scaring and remorseless account of Marxism—"An Atheist Providence Guaranteeing Utopia"—followed by an account of sociology, a Harvard creed born of insect societies and assaulted within its home university by what Flew calls the right left Marxists!

In the short concluding section "Progress, social Darwinism and an evolutionary perspective", Flew rightly will not draw "prescriptive conclusions from the neutrally descriptive premises of scientific discovery", but looks ahead, "Survival of the fittest", imposed by Herbert Spencer, is repudiated even within a Victorian context. "Man is the creature which can, and cannot but, make choices; and it is upon the senses of these choices that the future not only of mankind but also of almost all other species now largely depends." In 1953, Julian Huxley wrote "Man... need no longer regard himself as insignificant in relation to the cosmos." So, after thanks to Antony Flew, I must end. □

YOU DO NOT get much of a technical book for £5 these days, unless it is subsidised. This thick A4 reference work on all aspects of telecommunications technology is the result of a heavily subsidised joint project between British Telecom and the Association for Science Education.

A group of 20 science teachers visited various BT research establishments and operational sites for short courses last summer and learnt about the technology in use. They then went away and wrote about what they had learnt. The result is a loosely bound collection of 21 separate chapters on satellites, optical fibres, radio aerials, telephone exchange technology, digital code modulation and microwave radio links.

Although the book is aimed at teachers, and suggests test questions and experiments, by a happy coincidence it also makes a valuable reference work that would not otherwise be available. BT, and previously the GPO, has always been cagey

## Lines of communication

Telecommunications in Practice

edited by Brian Nicholl and Jenny Selfe, British Telecom Education Service, £5 pbk

Barry Fox



City benefits in rural areas: the latest in telephone exchanges

about publishing details of the technology used to carry speech and data signals around the country and across the world. Quite why BT now thinks it is safe to explain in some detail and in clear words how its equipment works is unclear. Perhaps it is an unforeseen spin-off from privatisation. Whatever the reason, BT's more open policy is welcome.

Because of its format, the book lacks an index, which is a pity. Suggestions for further reading would also be useful. So would a more robust binding. Because BT has used teachers to write the text, there is no coherent editorial thread. But most of the chapters stand alone as very valuable briefings on telecommunications technologies. Perhaps now BT will think about publishing a definitive, and inevitably more expensive, reference book covering all its areas of telecommunications expertise. □

\*Available from: British Telecom Education Service, 81 Newgate Street, London EC1A 7AJ.

IN SPITE of the familiar approval of the heartier among us, few people positively enjoy a cold shower. This book is the equivalent in intellectual terms, so it is hardly likely to be read by the thousands of people to whom it would do the most good, those who believe, or half-believe, or think that there may be something in, considering it's there in black and white, an assertion that pyramids can sharpen razor blades or that we are intelligent only because space travellers mated with Earthfemales.

It took me back to the days of my childhood and Sunday afternoons, stealing the newspaper from the head of my sleeping father, where it had been placed like a steeply-pitched roof, and reading, for example, that Jericho had been discovered, its walls flat as pancakes, thus proving that Joshua's trumpeter had been as efficacious as the Bible said he had. Or that reports of the expedition finding the Ark on Mount Ararat would shortly astonish the world, with pictures to prove it.

The Ark and its poetically attractive but practically absurd cargo is one of the most durable myths, of course, and it is the first one tackled by Stiebing Jr,

## Dismantling myths

Ancient Astronauts, Cosmic Collisions  
by William H. Stiebing, Jr, *Prometheus\**, pp 217,  
£16.95 hbk, £8.45 pbk

Roy Herbert

who is an associate professor of history at the University of New Orleans—somewhat dangerous territory. I should have thought, to start from in attempting a reasoned look at religious myth.

Not that the theories and stories about mankind's past he steadily examines, while keeping a firm grip on the cold water supply, are necessarily religious. Stiebing is fluently dispassionate on Atlantis, the alleged mysteries of the pyramids, the innumerable and sometimes hilarious "discoveries" of America, and wades into Immanuel Velikovsky and Erich von Däniken with the gusto and effect of someone wielding a fire hose. That has been done before, I know, but it is valuable to have all the refuting arguments for such powerful myths to hand. Besides, Stiebing can be succinct in demolition. Apparently, Däniken suggested that because an island in Egypt was named "Elephantine" that proved that it must have been

surveyed by some visitor in an aircraft, in ancient times. Otherwise, how would it have been known to the natives, with their feet on the ground, that its shape resembled that of the animal? Stiebing: "The ancient Egyptians called this island 'Yeb' or 'Yebu' (ivory) because it was a trade depot for ivory arriving from sub-Saharan Africa. The present name derives from the Greek translation of the Egyptian name; *elephantinos* means 'ivory' in Greek."

No collapse of any stout party will follow such evidence, for there are thousands, and possibly millions, judging by the sales of books about UFOs and Bermuda Triangles, the emotional lives of plants and joggling to cure every disease, who prefer to, or actually need to, believe such things. Most of us are familiar with the fanatic who has some claim or system that would revolutionise science, medicine, or world

history itself if only the vested interests and massive obstruction of dogma could be overcome.

The fact that, in the past, certain theories greeted with incredulity have been proved feasible is used as an argument to justify the claim of anyone now ridiculed. (The Gershwin song, "They all laughed", is based on this point, with lines such as "They all laughed at Wilbur and his brother when they said that man could fly. They told Marconi wireless was a phony, It's the same old cry." That could be the marching song of the Velikovsky Regiment.) Not the least interesting section of the book is the discussion of the reasons for the tenacity of popular beliefs and the general failure of scholars to examine them publicly.

It is a pity, then, that it is marred by incompetent editing, verging on the flagitious. Typographical errors are frequent. Prometheus's printers have no sign for "pi" in their founts and, most disconcertingly, one page is printed twice. The author deserved better than this. □

\* Available from: Mike Hutchinson, Prometheus Books, 10 Crescent View, Loughston, Essex IG10 4PZ.

"THE first patient in your morning surgery is a 32-year-old woman who has just read a book about food allergy. She has at last discovered what is wrong with her and is sorry she did not find out earlier. You find that a year ago your partner treated her for premenstrual irritability. She at first responded to diuretics, then to progestogens... At a time of stress she began to feel below par again. On a diet of lamb, pears and spring water she says she felt better than for some years—until she started adding extra foods according to the advice offered by the allergy book. Now all her problems are as bad as ever."

With due apologies to all whose sensibilities are offended, those recent sentences by Maurice Lessof in *The Practitioner* (vol 227, p 573) aptly summarise the attitude of most clinicians towards one of the most fashionable diagnoses of modern times. True Professor Lessof went on to acknowledge that specific food intolerances are real enough, with causes ranging from hereditary lactase deficiency to overenthusiasm for chicken vindaloo. But as reported last year in the *British Journal of Psychiatry* (vol 145, p 121) the majority of doctors are now convinced that most patients who believe they are allergic to dietary items

## Faith, hope and allergy

are simply wrong. Despite claims by commercial companies offering impressive tests to reveal whether the morning Scrunchies or the afternoon Gungielets are responsible for the evening itching, orthodoxy holds that such symptoms are not immunological.

Horizon's challenge in tackling *The Food Allergy War* (BBC 2, 1 and 7 April) was to approach the subject with both sympathy and rigour. Tony Edwards's programme focused on America's "clinical ecologists" and how in Britain "some respected doctors have begun to investigate their claims, with some startling conclusions". It began with a videotape of one arthritic cripple whose symptoms had "virtually disappeared" after being treated for beef and wheat allergy by Dr Marshall Mandell, disciple of



Bernard Dixon

neurotic,

pioneer clinical ecologist Dr Theron Randolph. Next, a lady whose body used to swell up, and who was so unhappy that she had had to ask her children to leave the room, improved following four days on spring water to clear the system. When given corn, however, her feet had begun to tingle again. Next, multiple sclerosis "became worse" after a patient ate banana. And when a hyperactive youngster was exposed to allergen following internal cleansing, "his original behaviour began to return". (He put his feet on the table and tried to kick his clinical ecologist.)

From the very outset, Edwards put across these and other stories with appropriate scepticism, intercutting criticisms from Professor Raymond Slavin and other members of the allergy establishment. Fair

enough. But his efforts to instruct us in double blind trials and the other protocols very properly insisted upon by that properly critical establishment were much less successful. It was not impressive, for example, when one small boy, incarcerated in a doctor's surgery all morning and challenged with stuff from four bottles, started to become restless after the fourth bottle—which happened to be the only one containing corn. Was this really supposed to be science?

Most of the action came from the US's private enterprise medical system, where it was hardly surprising to find former sceptics changing horses and joining the clinical ecology party. But the British reports were little more impressive—"dramatic results" (but no data) from irritable bowel work at Addenbrooke's, claims (but no facts) about migraine treatment at Great Ormond Street, and a deeply unconvincing "vaccination" by Dr John Mansfield. All this and no attempt to explain precisely why the *Annals of Allergy* was just one of several journals to have rejected papers in such a buoyant field. Perhaps Pioneer Randolph's beliefs really are being confirmed, as we were told. But there was literally nothing in this programme to buttress that confidence. □

## This week's contributors

Judith Hampson is Chief Animal Experimentation Officer with the RSPCA.

Jack Harris is a metallurgist based at Berkeley Nuclear Laboratories, Gloucestershire.

Ashley Morton is a consultant to the Wolfson Unit of Chemical Entomology.

Sydney Smith is an editor of *The Correspondence of Charles Darwin* (CUP, 1985).

# FORUM

## Forward with the Wallies

Advanced communications technology (tom-toms and two cleft sticks) allows Chris Schofield to report from Sulawesi

IT WAS inevitable, of course, that the ready wit of the combined services support personnel should quickly distinguish them from "the Wallies", the 17 scientists and entomologists in Indonesia for "Project Wallace" (*New Scientist*, 3 January 1985). Even the first trail cut through the jungle is labelled on their maps as "Wally 1". Yet the two groups work well together. Only two months into the expedition, the entomologists have amassed a huge collection of insects from the forest, together with information about abundance, host plants and insect behaviour.

The servicemen, who cook, clean, survey, cut trails, build bridges and generally organise, have caught the excitement of the project. Aided by frequent seminars from the scientists, most of them have begun their own carefully labelled collections of insects, and have improvised cunning devices from ration tins and nets to capture, breed and preserve them. Only the "paras", it seems, resolutely stick to their main interest—hacking new trails and carrying huge loads of equipment through the forest.

The Indonesians, too, are deeply interested in the project. Assisted by the British Embassy in Jakarta, they sort out documents and arrange transport for arriving scientists. They were amused by the packaging of the £250 000 worth of equipment on loan from the Ministry of Defence. It was delivered in five huge containers "provided" by the Argentines during an expedition to the Falklands. Nineteen armed motorcycle police proudly escorted it to the base camp, and presented only a modest bill for their services.

Teams of Indonesian students are already visiting the project to receive training in entomological techniques. Even the local beer company has arranged regular supplies of that essential commodity, and has set up gaily coloured parasols and tables outside the base camp. The camp itself is



still under construction, as indicated by a sign and a workmen's hut, but alternative accommodation, in what used to be the offices of the local irrigation company, plus some army tents, is so far satisfactory.

The forest, which makes up most of the Dumoga-Bone National Park in

Northern Sulawesi, extends from 211 metres altitude (plus or minus 5 metres, according to Captain Chris Dorman, who leads the surveying team) at the foot of the Project Wallace flagpole, to about 1600 metres in the central hills. Trails to two of the original Dutch trigpoints in the hills have already been cut, so the survey team is on schedule for the difficult task of remapping the terrain. Although humid, the lowland part of the forest appears to be in a "rain shadow" from the forested hills to the north, west and south, so it is much

drug-resistant malaria have been reported from Indonesia, he responded very well to treatment. Within three days, he was up and offering to cut trails through the jungle again.

The forest canopy is fairly open, and the trees, although more than 50 metres tall, have narrow profiles and fairly small leaves. As a result, more light reaches the forest floor and the underlying vegetation is much thicker than expected. It is dominated by *Rotans*—savagely barbed palms, referred to as trees with no fathers by those who become entangled in them. The pattern of vegetation is reflected in the insect studies. So far, most of the "action" seems to be on the ground, with relatively few species up in the canopy. Traps, designed to sample crawling insects, day or night-flying insects, carrion flies, dung beetles or mosquitoes, have been erected at strategic points on the forest floor, in the understorey, and even high up in the canopy. As Dick Askew—recently arrived from Manchester—commented, "There's so much going on, you can hardly find a good site to put up your own traps."

The largest and most active component of the expedition at present is the "Insect Diversity Programme", led by Jeremy Holloway of the Commonwealth Institute of Entomology. The aim is to relate the diversity and abundance of major insect groups to environmental factors such as habitat and the type of vegetation. These studies rely heavily on the fogging activities of Peter Hammond, Nigel Stork and Chris Lyal, from the Natural History Museum, London. Using a modified rifle, they shoot ropes high into the forest canopy to haul up an insecticide fogging-machine. Once in position, a remote radio-controller switches on the machine to blast out clouds of biodegradable insecticide. Specially placed trays then collect the insects which succumb and fall.

All the insects, from giant tiger-beetles to tiny fungus flies, are stored in preserving fluid to be carefully sorted back at the base-camp. Stork and Lyal have a wealth of background data from similar fogging studies in forests throughout the world (including Richmond Park), and are building up an archive of information about what goes on in different forest canopies.

As Alfred Russell Wallace himself remarked in his account of his travels in the Malay archipelago, over 130 years ago, Sulawesi seems "poor in the actual number of its species, yet wonderfully rich in peculiar forms, many of which are singular or beautiful and absolutely unique upon the globe". Although it is too early to confirm Wallace's observations about the number of species, because so many of the species collected during Project Wallace are new to science, it is already clear that the levels of endemism are remarkably high. In many insect groups, over half the species already found here are not known from anywhere



Who needs a butterfly net when you can use a fogging machine and rifle?

drier than other rainforests. It is also healthier, with few mosquitoes or leeches, and the service medical personnel are, professionally speaking, bored. They spend most of their time chasing butterflies, jogging, or helping to carry the huge loads of equipment to various sites in the forest.

The main biting nuisance, thought at first to be chigger mites, which can transmit scrub typhus, has been identified by Henry Disney as tiny *Culicoides* midges, which don't seem to transmit anything here. One of the Ghurka engineers went down with malaria, but, although several types of

else. This is also true of many of the vertebrate species, such as the troops of curious macaque monkeys which regularly hurl fruit at the entomologists.

Many of the mammals and invertebrates of the Dumoga-Bone Park are accorded threatened status by the International Union for the Conservation of Nature. So, apart from the scientific studies, the infor-

mation from Project Wallace will help to develop conservation and management plans to safeguard the unique fauna of this part of Indonesia. The project has another 10 months to run, and by then over 150 scientists from 19 countries will have contributed. Hundreds of scientific papers should emerge from this, the largest entomological expedition ever mounted. □

## Clinical ecology: a useful alternative

Julian Kenyon and George Lewith explain how it can complement medicine

**C**LINICAL ECOLOGY is a medical discipline which applies the idea that disease is wholly or partially caused by foods and/or chemical sensitivity. The subject first attracted interest from doctors in the US in the 1930s, where it has since grown into a specialty in its own right, with all the attendant razzamataz. In Britain, doctors have been slower off the mark, though interest was aroused in the early 1970s, when the Clinical Ecology Group, a society which accepts only medical doctors as members, was formed.

The Clinical Ecology Group, recently renamed, the Clinical Ecology Society, believes that clinical ecology is really part of conventional medicine. Most conventional doctors, and some clinical ecologists, do not accept this argument. Their "narrow" view of clinical ecology would appear to be both short-sighted and dull. A large number of alternative practitioners, some of whom are medically qualified, use clinical ecology in a more open-minded, but, in some cases, scientifically dubious manner. As a result, clinical ecology stands at an uneasy interface between conventional and alternative medicine.

Much of the controversy about food allergy results from a misunderstanding of the terms involved. Allergy, to the immunologist, defines a very specific and limited group of recordable and repeatable immunological reactions. If patients do not produce a positive response to a scratch test (where a small amount of food is scratched into the skin), or if the antibodies in their serum or intestinal tract do not change in response to a particular food, then food allergy cannot be a problem. However, in many patients, with no immunological proof of allergy, removal of certain foods from the diet results in a marked clinical improvement. This has been validated in double-blind trials (D. J. Abbotton, *Clinics in Immunology and Allergy*, vol 2, p 77).

This, then, is what clinical ecologists call a food allergy, and they are often, perhaps rightly, derided by conventionally trained colleagues. The terms food sensitivity and food intolerance have been suggested as a way out of the semantic dilemma, but the basic problem remains. How can we explain this phenomenon, when no immunological changes have been demonstrated? A number of possibilities have been suggested, such as pharmacological reactions (as, for instance, in migraine attacks, brought on by the consumption of



Total allergy or total nonsense? Britain's most celebrated victim, pop singer Sheila Rossall

food high in tyramine), or enzyme deficiencies (the reaction to milk, for example, in people with lactase deficiency). However, these mechanisms explain only a fraction of the many bizarre, reproducible findings unearthed by clinical ecologists.

One of the more fruitful ideas to come from alternative practitioners is that multiple sensitivity (or "total allergy syndrome", as it is called by the media) may result from one of many underlying causes. The most common problem seems to be a disorder in gastrointestinal function, caused by presence of abnormal bacteria in the gut. Some practitioners go on to claim that this condition, which they call dysbacteria, can itself have a number of causes, from psycho-neurotic behaviour to repeated or long-term antibiotic consumption. A complex causal chain then unfolds, which is compatible with the declared aim of alternative practitioners—attempting to treat the cause of illness rather than its symptoms.

In practice, causally-directed approaches to multiple sensitivity to food and chemicals are often very gratifying, resulting in the disappearance of the sensitivities and, in some cases, of true immunological allergies. This causally-directed approach to illness contrasts markedly with the therapeutic approach of conventional medicine, which, from the patient's point of

view, appears to consist of suppressing symptoms using drugs.

Controversy between conventional doctors and practitioners of clinical ecology is most rampant when it comes to the tests used to define the foods and/or chemicals to which the patient may be reacting. Conventional doctors usually rely heavily on scratch tests. These are inaccurate, if not almost random, in defining food sensitivities. Blood serum estimations of various immunoglobulins, particularly immunoglobulin E, have also been used, but have been shown to provide no clinically effective answers. Indeed, in one study, a diet for migraine patients based on the results of immunoglobulin E assessment was no more effective than random avoidance of certain foods. Conventional diagnostic approaches usually involve some *in vitro* test and are essentially reductionist; they fail to look at how the whole body reacts to a particular food or chemical.

Alternative practitioners claim that, because the reactions occur within the whole body, *in vivo* tests should be used. They have suggested various methods, ranging from recording the skin impedance over acupuncture points to measuring muscle strength when the patient holds a sample of the suspect food. Conventional doctors are probably rightly dubious of these techniques. However, their criticisms are largely based on their own beliefs rather than objective observations, and most have made no effort to understand the underlying principles.

One of the tests used by alternative practitioners is the cytotoxic test. This is based on the observation that white blood cells, in food sensitive individuals, undergo changes of varying severity when placed in solutions of the food to which the patient is reacting. The results are variable, however; one private British clinic failed to obtain reproducible results on duplicate blood samples taken from the same subject at the same time.

At present, clinical ecology is an emerging discipline, much of which is poorly understood. The evidence that exists strongly suggests that some diseases, in some patients, are definitely the result of food and chemical sensitivity. Consequently, it behoves the medical establishment to take these ideas seriously and investigate them thoroughly. Clinical ecology also raises fundamental questions about how doctors perceive and treat disease. If it succeeds in forcing doctors to perceive disease in a causally-related manner, then the conflicts and debates that surround it will be of enormous value. □

## Why scientists keep it obscure

Ted Nield reveals the motives behind the jargon and gobbledegook

THE WORD "mystique" should have the same effect on a scientist as the word "culture" had on Field Marshall Goering. For, as he or she reaches for his or her favourite firearm, the reflection should be that mystique is nothing more than a sense of awe towards something we know nothing about. It's our old friend ignorance in sheep's clothing.

I was reading Sally Vincent on the subject of the sociobiologist (*Radio Times*, 2-8 March), of whom she says: "He has the mystique of a scientist." Now, sociobiologists may not be your favourite breed, in which case you might be tempted to assert that they have the mystique of a witchdoctor. This would imply (rightly or wrongly) that they live by the creation of a mystique, and nothing else. But science is there to dispel mysteries, not create them. So why does the public see those who practise it as magicians? I am afraid that we could moan about raising public awareness until all the sacred cows come home, but the fact is that scientists themselves are to blame, and know very well that they do it deliberately.

That knowledge is power is nowhere better demonstrated than in the spectacle of people trying to keep it secret, and there has been plenty of that around lately. We can do it to save embarrassment, or so that nobody can attack what we say. Patrick Jenkin recently refused to reveal how he calculates rate-capping limits. Who can blame him? Access to information gives you the advantage—but can this be the motive among scientists?

I think not. It is subtler, more everyday than that. I remember how my father, a teacher, was once moved to write (though not to post) his first and last letter to *The Times*. It concerned a bricklayer who had been building him a wall, with whom he had talked at length. As soon as he broached the subject of bricklaying, however, the conversation was brought swiftly to a halt. "Ah," said the bricklayer, "now you're picking my brains."

He was being asked to reveal the secrets of his trade, learnt during a long apprenticeship and probably enshrined in a City and Guilds certificate. This knowledge made him a craftsman rather than a labourer, and to divulge it might betray his position as a skilled man. Maybe he really believed that explanation of the technique would enable a complete novice to build a perfect wall. But what he feared was that, once a member of the public was told how it was done, the notion that, "it's a skilled business, you need a specialist", would be eroded.

Scientists today are no different from the craftsmen of old. The craftsmen's guilds existed to ensure that only the initiated

were privy to the truth. There was only so much room in the world for masons, coopers, cordwainers and sagger-makers' bottom-knockers. Of course, no one would expect to become a Stradivari with a DIY



Scientists have much in common with the sagger-makers of old

carpentry book, but the principle of obscurantism is always most strenuously held by those who know (in their hearts) that what they do lies mostly within the compass of any reasonably competent person.

Technical language, in craft and science, exists for two purposes. One is to allow specialists to talk with ease about things for which common parlance has no terms. The other is to bamboozle the uninitiated into thinking there's more to the subject than

there really is. What professional body does not use this technique to impress upon the government and the public how essential their mysterious abilities are? What hapless academics do not cram the latest buzzwords into their dead-duck research proposals in a (not always) vain attempt to breathe a semblance of life into grant applications? What, after all, are scientists but professional men and women who, in the words of John Galloway (*New Scientist*, February 28, p 43) are merely "trying to get on"? The mystique of science serves some very important ends which it may not be in their interests to dispel.

As convenor of a conference, I once had a 150-word abstract sent to me. Despite being myself a specialist in the subject, I was unable to understand anything of the paper being described. Yet the sentences were correctly constructed, and gave a semblance of logic. The problem was vocab.

I wrestled with it for a whole day. Eventually, by combing references on related topics in American journals, and by examining some outdated glossaries, I worked out the main thrust of the implications in this great work. If I mentioned them by name, perhaps a non-paleontologist would not see the sense of it. But the contention turned out to be no more complex (and not a lot more significant) than "some oranges have pips". Not an important observation, perhaps, but hardly a world-shattering piece of news. Put like that, indeed, a little short on mystique. But then, great thoughts, simply expressed, do have the beauty of simplicity. □

## Fast reactors, corrosion and smells

More lines in the Westminster pool

THISTLE DIARY



Tam Dalyell MP

Department of Energy, responsible for the UK Atomic Energy Authority, expects that those principles will include the possibility of cross-investment between the utilities in any demonstration fast reactors that may be built in Europe.

Of course, there is the caveat that any definite proposal for such investment should be subject to a specific agreement, requiring the approval of the respective governments.

I'm all for such progress, but I can imagine that there will be much indignation and binding-in-the-marsh among groups who

ON fast reactor collaboration the Central Electricity Generating Board is currently negotiating with utilities in France, Germany and Italy the principles of future cooperation. Alastair Goodlad, Britain's under secretary at the

oppose civil nuclear power, especially when they tumble to what exactly is going on.

JEFF ROOKER (Birmingham Perry Bar), he of the notorious Rooker-Wise amendment on pension benefits, which, to James Callaghan's wrath, cost the Labour government hundreds of millions of pounds, has a knack of asking highly pertinent questions. He now wants to know the significance of the limitation given in the Department of Environment circular 28/84 to the eligibility of owners of prefabricated reinforced concrete houses designed before 1960. Specifically, Rooker wonders whether dwellings designed after 1960 are not expected to be liable to cracking and concrete spalling to a significant extent, as a result of corrosion of the embedded steel reinforcements.

Ian Gow, the housing minister, replies that there are two distinct types of prefabricated dwellings in Britain. Those designed just after the Second World War were intended to provide, in the main, two-storey houses, and to be assembled by hand. That meant that the prefabricated sections had to be very light and slender.

Put simply, Ted Nield is a scientific writer.

Because they are slender, there is little protection for the steel reinforcement. The Building Research Establishment finds that all prefabricated reinforced-concrete houses built before 1960 are likely to be affected by the processes of carbonation and attack by chlorides. Such effects lead to corrosion of the reinforcement and consequent cracking of the concrete. Prefabricated reinforced-concrete dwellings designed after 1960 were generally made by casting whole walls and doors as single components. These are massive and robust, and were used not only to build houses but flats of up to 20 or more storeys. Because of differences in design, and improvements in the quality of reinforced concrete, the steel in these components is better protected.

Now says that there is no evidence that the main load-bearing components of these buildings are liable to rapid deterioration, or to consequent cracking and spalling found in prefabricated reinforced-concrete houses of the previous generation.

MPs of all parties and shades here there will be no more cuts in the budget of the Building Research Station. As a nation, we need an organisation to tackle the ongoing effects of carbonation and chlorides.

STINKS can be kicked up in more ways than one. People tell you that they think goats smell. Let them try sniffing cormorants! Since these birds depend mainly on fish for their diet, you should not be surprised. Cormorants are thus the competitors of anglers and fishermen, and therefore tend to be given a bad press. So I



am glad that these much maligned creatures have found a champion in Sarah Kilroy Silk, MP for Ormskirk.

Michael Ancram, under secretary of state at the Scottish Office, tells him that the last survey of cormorants was made in 1969-70. Then it was established that there were 3671 breeding pairs in Scotland. The Nature Conservancy Council advises Ancram that it sees no evidence to suggest that the number of cormorants is declining.

I am heartened to learn, however, that the British Trust for Ornithology will be making a pilot study of these magnificent birds. The aim will be to determine their present number. Yet, come to think of it, I would rather that the cormorants did not come back to Linnithgow Loch. If they did, it is a certain bet that the rod-and-line brigade would be at my surgery door asking what I was going to do about the critters. Cormorants, like gypsies and open hospitals for the mentally ill, should be encouraged, but not, people say, *chez moi*! It's a hypocritical world. □

## View from the bottom

The future for science looks bleak, says Sarah Guthrie

THE PESSIMISM of the letter from Sir Martin Ryle (*New Scientist*, 14 February, p 36) shows the accumulated disillusionment of a lifetime in science. But fears for the future of science are not confined to the older generation. Even from the bottom rung of the scientific ladder, things look pretty bleak. Science has a serious malaise, and most of us are too frightened even to admit it. Many establishments face financial extinction. Where money is still forthcoming, defence is the main beneficiary. Hard-won advances are perverted as, for example, in the case of nuclear weapons. It is tempting to agree with Ryle's conclusion that, "in some cases, the resulting evil outweighs the good."

Was Ryle right in believing that the only course of action is, in some areas, to stop fundamental science? I think so, but only if the cuts are made in the right areas. Defence research is an obvious candidate. But the shadowy implication of the question, especially in the prevailing economic and social climate, is that fundamental research in many areas should be stopped. This, I believe, would be wrong. Pure research in many subjects is valuable, provided it is controlled and used correctly.

Using economic decline as an excuse, the British government has cut back on crucial areas of research. At the same time, it misdirects existing funds to the wrong areas. Defence has not suffered; a recent survey showed that 55 per cent of research expenditure goes on defence-related projects. Elsewhere, the cuts made negate the holistic strategy essential for healthy science. Attempts to make science commercial surely deny any higher ideal of the general good it might produce. The government has divided academia by its "either/or" mentality, leaving Cambridge and Oxford intact, while seriously disabling universities such as Aston and Salford, once at the forefront of Britain's technological development. Heads of departments have had to make agonising choices. Should they force premature retirement on older members of staff, or sack young lecturers?

Financial stringency is bound to hinder good science. The paucity of grants now allocated by bodies such as the MRC and SERC means that scientists waste much of their time trying to write convincing grant applications. Many scientists, especially those with families, are dissuaded from research by the financial uncertainty of the three-year grant system. Of course, lack of finance causes competition, which, in the short term, may promote excellence. But eventually it leads to bitterness between colleagues, and is injurious to the long-term development of coherent research.

Lack of social responsibility is hardly surprising when livelihood is at risk. Grow-



Sir Martin Ryle: wished he had been a farmer

ing unemployment increasingly forces people into jobs without consideration of the moral and ethical implications. So spheres of work such as the defence industry become gradually more acceptable, and we begin to think the unthinkable.

The present government preaches the doctrine of self, whereby individuals

have to fight for their own interests. But how should the individual best serve society? There is no guidance, either from the government, at school, or at university. In science, any association between individual responsibility and the good of the whole is spectacularly lacking. Science is, in any case, a solitary pursuit. Many scientific departments are full of people working in diverse fields, with little idea of togetherness or common objectives. If anything, working in isolation is encouraged, to enhance career prospects, or keep a patent on original ideas. Excessive specialisation is promoted for the same reason. Research tends to progress haphazardly, with a view to obtaining and publishing results, often without regard to the moral implications.

So what can scientists do to ameliorate the condition of science. First, we should restore to science its rationality. I think it is melodramatic to take the view that all types of fundamental research should be stopped. Certainly, research into nuclear weapons is scandalous and unnecessary. But in other areas we should seek to make reasonable rules circumscribing scientific activity. The government seems incapable of making moral assessments of our rapidly increasing scientific knowledge. Often, sensible legislation on, for example, the disposal of nuclear waste or experimentation on human embryos, comes too late to prevent a furore.

We cannot doubt that pure research is important, not least because potentially it is applied research. On the individual level, though, scientists engaged in such projects could be urged to consider the possible applications. Some areas of science may have foundered in the absence of constructive proposals for putting funds to good use. In the case of human embryos, for ►



Sarah Guthrie is a PhD student in London.

► example, few scientists have supported their criticism of prohibitive legislation with concrete proposals for experiments that might benefit mankind. By avowing their positive aims, scientists might succeed in turning research in different, and better, directions.

More importantly, scientists must find a group identity. In response to nuclear weapons, for example, they could form an influential lobby and be vociferous in opposition. Much headway has already been made by groups such as Scientists Against Nuclear Arms and the Medical Campaign Against Nuclear Weapons. Professional sympathy should encourage us to make links with other countries. The mobilisation of scientific expertise and articulate opinion on important issues is urgently needed. Many scientists, more addicted to coffee-room conversation than action, will have to pay the price of a little of their sang-froid, but it will be worth it. Science is not sacrosanct; its aims have to be fought for.

Any hope for the future will rely on an increased sense of responsibility in the way we apply science, both individually and at the level of government. If government responds, we may by degrees attain a state where science puts the proper interests of mankind before commercial and selfish gain. If not, I might as well burn my PhD thesis and become a farmer, as Ryle wished he had done. □

## ENIGMA

No 303

### Some dominoes

By Stephen Ainley

MOST OF a full set of dominoes has been arranged in a 7 x 7 block with a hole in the middle. Please mark in the boundaries between the dominoes. There is only one answer.

|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
| 0 | 6 | 0 | 4 | 4 | 4 | 3 |
| 0 | 2 | 3 | 2 | 2 | 2 | 5 |
| 0 | 5 | 4 | 6 | 6 | 0 | 5 |
| 4 | 1 | 1 |   | 4 | 1 | 1 |
| 4 | 5 | 6 | 5 | 5 | 0 | 5 |
| 6 | 3 | 3 | 3 | 2 | 6 | 5 |
| 2 | 1 | 0 | 6 | 1 | 6 | 4 |

A £10 book token will be awarded to the sender of the first correct solution opened on Thursday, 25 April 1985. Please send entries to Enigma No 303, New Scientist, Commonwealth House, 1-19 New Oxford Street, London WC1A 1NG. The Editor's decision is final. The winner of Enigma No 300, "Changes, Etc", was Richard Kerraway, of Norwich.

Answer to Enigma 300  
Changes etc

Secretary, Entertainment Office, Vice-president, President, Treasurer.

A TALE was going the rounds at the British Psychological Society's annual shindig, at University College, Swansea, last week, about a psychologist who found himself sitting beside fighter pilots at the uncomfortable end of a centrifuge. The psychologist wanted to find out more about pilots' vision when they black out during tight manoeuvres. Unfortunately, he was more used to the rigours of the senior common room than the comforts of a supersonic aircraft, and tended to pass out before his fitter and younger subjects did.

After several fruitless and nauseous trips, it was clearly time for a rethink. It turned out that the effect under study could be simulated by pressing on the blood vessels serving the eyeball.

The psychologist got his results, and presumably his revenge, by lining up some of the RAF's finest and asking them to poke themselves in the eye. □

DELEGATES at Swansea were also amused by the university's halls of residence. There are three halls. Each has eight floors and two lifts. One lift (for the boys) calls only at even-numbered floors. The other (exclusively for girls) stops only at the odd numbers. "What," wondered one delegate, "do they use the stairs for?" □

WE ARE PLEASED to report an April fool that has made a fool of the joker. Fraser Peacock, a subsidiary of the Granada television group, duplicates video tapes for film companies. The company can make hundreds of copies at a time on its banks of VHS and Beta recorders.

Last week, just after the Japanese firm Sony announced its plans to sell combined cameras and recorders for 8-millimetre video, Fraser Peacock announced that it would be buying equipment to duplicate films on 8-millimetre video. We are using camcorders with "cam" parts stripped out, it said. At least one video trade journalist started writing an article about the scheme. Other articles may already be in the pipeline for publication. But of course it was all a big joke for 1 April.

It's not a joke in Japan. Engineers there, who have penetrated Sony's camcorder, report that the electronics are designed to be separated easily into a camera and a recorder. Before long, Sony plans to launch just such a recorder.

Sony's machine has a choice of two tape speeds, which give up to three hours playing time from a single cassette. This is more than enough to duplicate a feature film.

In private, Sony has always seen 8 millimetre as the future format for domestic video. Journalists who fell for Fraser Peacock's little joke need not kick themselves: they are only a few months ahead of the news. □

SPEAKING of April fools, London's Zoological Gardens is trying to reach out to a new audience of zoo-goers. But it really ought to develop its sense of humour. On the first of the month it answered callers with a stony recorded message: "This is London Zoo. A lot of people telephone us on April Fool's Day. If you have a genuine inquiry, please contact the operator." □

## FEEDBACK

REMEMBER those television pictures of the heroic medical community of Bhopal, swamped by tens

of thousands of victims from the escape of gas last December? According to one French doctor who went to the scene, there was plenty that we didn't see.

When the doctor, a member of *Médecins sans Frontières*, offered his services, the locals told him to go away. The story was that Western governments had been sending out observers posing as doctors to assess the way that medical services cope with such a disaster. Readers may draw their own conclusions on the need for such data.

When our genuine doctor persisted, an Indian doctor tested him by holding up an X-ray. "What's this?" he demanded. "Why, that's just an ordinary case of pulmonary TB," the Frenchman said. "OK, you'll do," was the verdict. □

IN TIME-HONOURED fashion, Feedback has two pieces of news for gamblers this week. The good news, according to the American Physical Society, is that tossing a coin is not such a risky business after all. The bad news is that you need a perfect coin and a mechanical tossing machine to be sure of the outcome.

Thinkers have been trying to calculate the probability of turning up heads since 1650 at least, when Pascal and Fermat analysed games of chance. The problem was that, although many equations give predeterminable solutions, in practice the results are completely random. All we have learnt is that, after turning up tails five times in a row, you are no more likely to turn up heads than at the beginning of the experiment.

However, Vladimir Vulovic and Richard Prange, of the Institute for Physical Sciences and Technology at the University of Maryland, have cast new light on the problem. With an "idealised coin", "randomness comes from the inability of the thumb and arm to toss the coin accurately, as well as imperfections in the floor, etc."

"In other words, with sufficient care and practice, or with a precision mechanical tosser, the outcome of a coin toss can be predicted." All Feedback can advise gamblers is, beware of the idealised coin. □

PART TWO in the continuing series of lies, damned lies and statements by government press officers. While researching a story on the Customs and Excise's new computer (*New Scientist*, 21 March, p 3), our reporter asked customs press office where the computer was. "In London," was the reply.

In fact, as we later discovered, the computer is at Shoebyrness, near Southend-on-Sea. We went back to the press officer, and asked him again. He came up with the trusty, but well-worn, "It is not Customs and Excise policy to say..." etc, etc. In fact, the government publishes a list of which computers it owns, and where they are.

As an example of government mis-statements and cover-ups, it's hardly in the Clive Ponting league. But it makes other government press statements that much harder to believe. □

## LETTERS

## Optical fibre

We read with interest your article "The new-looking optical fibre" (Technology, 14 March, p. 23).

We feel that your statement, "The dispersion shifted fibres are not as good as transmitting data at high speeds as the single mode fibres with lasers" is wrong, and are of the opinion that in fact the opposite is the case. We have achieved 107 kilometre data transmission at a rate of 1300 megabits per second using dispersion shifted fibre and simple lasers.

This result has excited us because not only is this a significant increase in performance for dispersion-shifted fibres with low-cost multiple-frequency lasers but it parallels results achieved in single-mode fibres with expensive single-frequency lasers. This means that in the near future 565 Mbit data rate transmissions over 60 kilometre will become commercially significantly cheaper and more reliable.

I hope you find our results as interesting as we do.

R. Mirauer  
Plessey Research (Cuswell) Limited  
Tonchester  
Northants

## CERN gang

There are, I suggest, two other good reasons for Britain continuing in membership of CERN, beside those set out in Chris Damerell's article (Forum, 14 March, p. 36).

The first, which is utilitarian, is that many technological developments occur in the course of designing and building major accelerators—developments in electronic instrumentation, materials handling, civil engineering and so on, all of which are directly and immediately applicable in the economy. Such developments are freely available for commercial exploitation by anyone who cares to pick them up and can live with the fact that, by the same token,

the development cannot be patented. Being a member of the organisation, however, gives us a head start if we are prepared to take it.

The second reason is more abstract but much more important. CERN is a demonstration of international cooperation that works. The reasons may be disputable perhaps because it has been left to scientists, perhaps because most politicians find the whole business totally incomprehensible, perhaps because the primary outcomes are not of any economic benefit in the short term. Whatever the reason, in my view a working proof that men and women from different countries can join in an effective enterprise is worth every penny of our subscription. That what comes out is good physics is a sizeable bonus.

Geoffrey Hubbard  
Council for Educational  
Technology  
London

## Quaint customs

Perhaps you will allow me to comment on the article "Computer defects upset drugs crackdown" (This Week, 21 March, p. 3) about the Customs and Excise Departmental Reference and Information Computer (CEDRIC).

Connor makes a number of misstatements but the main thrust of his article is that CEDRIC is a disaster. That is not true. It is working well and is proving a valuable tool for our drugs investigators. Moreover, it does not suffer from an inability to cross-refer as Connor suggests.

Although STATUS has been used for similar applications by a few other agencies, the design of the CEDRIC system broke new ground in a number of respects. Like most pioneering projects it suffered teething problems but these have been resolved in a spirit of goodwill by cooperation between Customs and Excise, CCTA and Honeywell

Information Systems. The system will shortly be included in the List of Computers in Central Government.

Before he wrote the article Connor spoke to our Chief Press Officer and was told that there was no truth in the suggestion that CEDRIC had fallen short of our requirements and that we were well satisfied with its performance.  
L. D. Hawken  
H.M. Customs and Excise  
London

## Patently clear

Barry Fox reports that patent application 8312589 on the Sinclair trike has not been published (Patents, 28 March, p. 28) and asks "does Sir Clive have friends in places high enough to bend the patent rules? Or, is the Patent Office now running so inefficiently that it cannot publish as required by law?"

Fox overlooks the fact that many applicants deliberately decide not to take one of the procedural steps (for example, filing a request for search) necessary to take their application through to the publication stage. As a result, little over half the applications filed at the Patent Office are published. In the light of this it is apparent that there is nothing sinister in the non-publication of application 8312589 and that Fox's allegations of rule-bending and inefficiency at the Patent Office are without foundation.

Feter Bentley  
Patent Office Examining Staff  
Association  
Patent Office  
London

## Personality tests

In the article "How to pick the personality for the job" (31 January, p. 12) Ghislaine Hubbard refers to the growth of personality testing in graduate selection.

As the British publishers of the 16PF and several other personality measures, we consider that Hubbard's article presents

IF THEY CRUMPLE IT UP AND CHUCK IT AWAY, WE MAKE THEM EXECUTIVES



a one-sided view of the state of the art. It is true that the occupational personality questionnaire (OPQ), to which the article was largely devoted, is the most recent test to become available, but it does not represent a major innovation in personality testing.

It is particularly unfortunate that the 16PF is referred to in the past tense. The 16PF is alive and well and has been adopted by many leading companies in Britain as a selection and management development tool. Over the years, users have collected a large amount of their own validity data on this test. In addition, the Gordon personal profile and inventory meets criteria of reliability and stability agreed by contributors to Hubbard's article as important in this area. By contrast, the reliability and predictive validity of the new OPQ has still to be demonstrated.

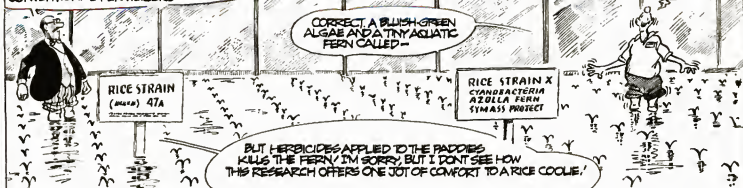
Your readers should be assured that, in this area, the tried and tested has many advantages over the new.

Tim Cornford  
NFER-Nelson  
Windsor  
Berkshire

We welcome short communications. We reserve the right to edit letters. Letters can be sent to Letters to the Editor, New Scientist, Commonwealth House, 1-19 New Oxford Street, London, WC1A

## GRIMBLETON DOWN

I'M NOT WITH YOU. BIGGER YIELDS MEAN MORE SPENT ON FERTILIZER, BUT A CONTROVERSY SYMBIOTIC ASSOCIATION BETWEEN CYANOBACTERIA AND A PLANT GROWN WITH RICE FIXES DOUBLE THE AMOUNT OF NITROGEN IN THE SOIL THAN CONVENTIONAL FERTILIZERS



## Bill Tidy

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Appointments and situations vacant

## Product Specialist

Infra-Red

Following recent growth of our infra-red business, we now wish to expand our product marketing support, with this new appointment.

Candidates will be of at least first degree standard and have gained an authoritative knowledge of infra-red spectrophotometry. Probably aged under 35, the successful applicant is likely to be able to show distinction in a sales or marketing environment although chemists with outgoing personalities from leading analytical laboratories will be considered.

As a member of the international Philips Group, we offer excellent conditions of employment including attractive salary, 25 days holiday, subsidised canteen, group pension scheme and generous relocation expenses where necessary.

If you are highly motivated, an excellent communicator and excited by the prospect of joining a dynamic young team operating in an international setting, write or telephone for further details and an application form to:

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Mrs Carole Taylor, Personnel Officer,  
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Tel: (0223) 358866.



**PHILIPS**



**Southampton  
THE  
UNIVERSITY**

DEPARTMENT OF  
PHYSICS

### TEMPORARY LECTURESHIP/ TEACHING FELLOWSHIP

Applications are invited for the post of Temporary Lecturer/Teaching Fellow in the Department of Physics. Duties will include some lecturing, tutorial teaching and laboratory demonstrating. It is hoped that the successful applicant will have research interests in experimental solid state physics or biophysics, compatible with those existing in the Department. The starting date will be September or October 1985 and the post will be for a period of two years. The starting salary will be at an appropriate point towards the lower end of the lecturership scale. Further particulars may be obtained from Mr D. A. S. Copland, Staffing Department, The University, Southampton SO9 5NH, to whom applications (seven copies from UK applicants) should be sent not later than 3 May quoting Ref 2141.

## TOPEXPRESS LIMITED CAMBRIDGE

### Research Scientists

We require research scientists to join a newly formed team of mathematicians and engineers who are developing novel systems for the active control of noise and vibration. This research and development programme is aimed at improving the understanding of the fundamental limitation on such control systems and designing them to approach those limits in practice.

Candidates for this position must be bright and enterprising, and able to organise their own research in useful directions. A first class science degree is essential, together with either a PhD or at least three years experience in acoustics, control or related fields. Other opportunities also exist for scientists of a similar calibre in the fields of signal processing and fluid mechanics.

Topexpress, a scientific consultancy, has been established for six years and now employs some thirty scientists working on long-term research projects. Other work in the company includes signal processing, structural acoustics, aeroacoustics and other wave phenomena studies. We provide an informal working environment in central Cambridge and we encourage publication of research findings. We offer an attractive salary and a range of benefits including a share of the company profits.

If you are interested please write with a curriculum vitae and the names of two referees to Colin Ross, Topexpress Limited, 13/14 Round Church Street, Cambridge CB5 8AD.

HERMANN OHLTHAVER INSTITUTE  
FOR AERONOMY

DEPARTMENT OF PHYSICS AND  
ELECTRONICS

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Applications are invited from suitably qualified candidates irrespective of race, colour or creed, for the following posts:—

### SENIOR RESEARCH ASSOCIATE

To work in a new group investigating the middle atmosphere by means of a tunable dye laser. Applicants should have some research experience, especially in the laser and electronic fields.

Salary negotiable on the Senior Lecturer scale R21 354 - R28 086. Travel assistance available.

### RESEARCH STUDENTSHIPS (two)

Leading to the PhD or MSc degree, in the same field. Postdoctoral applicants will be considered. Remuneration up to R10 000 for PhD or R7000 for MSc. Travel assistance negotiable.

For further particulars contact:

The Director  
Prof J. A. Giedhill  
PO Box 94  
Grahamstown  
6140 South Africa.  
Telex 24-4226 SA  
Telephone: 027-461-7128.

UNIVERSITY OF SOUTHAMPTON  
RESEARCH FELLOW IN  
CHEMICAL PATHOLOGY

Applications are invited from graduates in biological science to work on a project funded by the Wellcome Foundation to investigate the biochemical basis of a particular type of drug-induced arthropathy. The work will be based in the Department of Chemical Pathology and Human Metabolism, Southampton General Hospital. Applicants should have a good first degree and at least three years relevant post-graduate research experience in cell biology/biochemistry. The post is for 2½ years, starting around May/June and the salary will be on the University's Research Scales. Additional information about the job can be obtained from Ms Anne Burks Tel 0703-777222, Ext 3937. Applications (two copies) to include a CV and the names, addresses and telephone numbers of two referees should be sent to Mr A. J. Small, Staffing Department, Southampton University, Highfield, Southampton SO9 5NH before 30 April, 1985. Please quote ref. no. 85/14/AJS/NS.

## Tropical Development and Research Institute

The TDRI is one of the scientific units of the Overseas Development Administration and collaborates with the developing countries to solve agricultural and health problems.

## Head of Termite Ecology and Control

... to join a multi-disciplinary organisation based in the Applied Ecology Department in London. You will lead a small specialist team engaged in research and development of termite control for agriculture and forestry. You will be expected to spend some time in developing countries.

You must have a good honours degree in Biology, Zoology or Ecology and at least 4 years' appropriate post-graduate experience. A higher degree with specialisation in termite ecology advantageous.

**Appointment as Senior Scientific Officer. Ref: SB/21/JD.**

## Meat Scientist

... to join a team in the Animal Products and Feeds Department based in Cuiham, Oxon, investigating post-harvest aspects of fish, meat, hides and skins, dairy products, animal feeds and mycotoxins. You will be expected to plan and execute applied research in meat technology, both in the UK and overseas; provide advice on meat handling and processing in developing countries.

You should have a degree with 1st or 2nd class honours in a relevant discipline, such as Food Science or Animal Biochemistry and have at least 4 years' post-graduate experience, preferably in Meat Technology. Experience in Hides and Skins Technology advantageous.

**Appointment as Senior Scientific Officer. Ref: SB/22/JD.**

**SALARY:** £9325 - £12050, £1300 higher for the London post.

Starting salary according to qualifications and experience.

**SALARIES UNDER REVIEW.**

## Royal Botanic Gardens, Kew

There are currently the following opportunities in the Herbarium, the work of which will cover the following areas:-

## Advice and Research on Plant Conservation

You will be responsible for advice on plant conservation, including Kew's statutory role in relation to the Convention on International Trade and Endangered Species, and will be involved in research into potential plant conservation problems and identification of possible research areas; become familiar with the national and international conservation legislation for plants, and maintain a data-base for advice in relation to Kew's conservation role.

You should have a good honours degree in a relevant scientific subject; or an equivalent qualification and must also have a knowledge of the general conservation movement. Participation in plant conservation activities would be an advantage. **Ref: S/6502.**

## Curation and Taxonomic Research

You will be involved in curation, general naming and the development of a taxonomic research programme on either the Compositae or Cyperaceae family, and prepare floristic accounts in relation to Kew's floral commitments. There are two appointments. For the **Cyperaceae** post, curation and naming of related families will also be required.

You should have a degree in a relevant scientific subject; or an equivalent qualification. **Ref: S/6503.**

**Appointment as Scientific Officer £6635 - £8880 (including £730 intermediate London weighting) with starting salary according to qualifications and experience. SALARIES UNDER REVIEW.**

## Food Science Division, London Opportunities with the Ministry of Agriculture, Fisheries and Food

## Mathematician

You will provide a statistical and mathematical service to scientists. This will involve the interpretation of chemical analyses of food and of surveys of food consumption. Work includes providing application programs in FORTRAN or APL, using computer packages, eg SPSS, GENSTAT and PLOT 10, and applying mathematical models to problems of dietary consumption.

You should have a 1st or 2nd class honours degree or an equivalent qualification, in mathematics or statistics or in a natural science if you have adequate knowledge of mathematics and statistics.

**Appointment as Scientific Officer Ref: SB/64/AE.**

## Fisheries Laboratory, Lowestoft

## Statistician/ Mathematician

The Research Support Group of the Fisheries Laboratory provides an expert technical information and programming service to scientists engaged in fisheries and aquatic environmental research projects. You will analyse data arising in many disciplines using a wide range of statistical techniques. Various computer packages are employed, but new programs may need to be developed for specialised applications. There is a commitment to work at sea on research vessels.

You should have a good honours degree or equivalent qualification in mathematics with specialisation in statistics. A knowledge of computers and programming would be advantageous.

**Appointment as Scientific Officer Ref: SB/92/AD.**

**SALARY:** £5905 - £8150. Starting salary according to qualifications. Up to £1300 higher in London. **SALARIES UNDER REVIEW.**

For further details and an application form (to be returned by 3 May 1985) write to Civil Service Commission, Alencon Link, Basingstoke, Hants RG21 1JB, or telephone Basingstoke (0256) 468551 (answering service operates outside office hours). **Please quote appropriate reference.**

The Civil Service is an equal opportunity employer

**Scientific  
Civil Service**

# Technical Appointments

## — Water Treatment

The Water Specialities and Services business of Albright & Wilson, winner of the Queen's Award for Export in 1983, has two technical vacancies arising from its plans to expand the business. Both posts will be based at Oldbury in the West Midlands.

### Technical Service Chemist (£7,300 p.a. to £9,200 p.a.)

The successful candidate will be required to carry out laboratory work associated with the promotion of the Aquante water treatment programmes and the servicing of existing accounts. Additional duties will involve carrying out trials on the sites of potential and existing customers. With experience, he or she will be expected to contribute new ideas to the development of improved water treatment methods.

Applicants with an aptitude for practical work must be qualified to a minimum of HNC standard in Chemistry and extensive problem solving experience in the water treatment industry is essential, with particular emphasis on scale formation and corrosion.

### Technical Specialist — Oilfield Chemicals (£7,300 p.a. to £10,000)

The main duties will entail the examination and formulation of products for oil field and water flood applications. In addition, development of new products and chemical blends together with providing an after-sales service to customers are important features of this job. There will be a requirement to supervise field trials both in the UK sector of the North Sea and abroad.

Candidates must be qualified to HNC as a minimum requirement and ideally should hold a degree in Chemistry or Chemical Engineering. Considerable experience in product application formulation technology and problem solving associated with oil production and water injection is essential, together with experience of emulsion breakers, corrosion inhibitors, biocides and flow improvers.

The salaries indicated above will be reviewed in May and the Company operates non-contributory pension and life assurance schemes. The annual holiday entitlement is five weeks.

Assistance with relocation expenses will be given where appropriate.

Applicants, (male or female), should write or telephone for an application form to: Division Staff Manager, Personnel Department, Albright & Wilson Ltd., Albright & Wilson House, Hagley Road West, Oldbury, Warley, WEST MIDLANDS B68 0NN. Telephone No. 021-429 4942 Extn. 402.

**ALBRIGHT &  
WILSON LTD**



Water Specialities and Services Business,  
Phosphates Division

Albright & Wilson is  
a Division of Celanese

### LINCOLN COLLEGE (University College of Agriculture) New Zealand

#### LECTURER IN CROP

#### PHYSIOLOGY

Applications are invited for the position of Lecturer in the Department of Plant Science. Applicants should have a postgraduate qualification and research experience in crop physiology, preferably combining a sound knowledge of physiological principles with personal experience of crop or pasture production. Teaching at undergraduate and postgraduate levels will necessitate competence in such topics as soil relations, photosynthesis, plant competition, etc.

Commencing salary will be paid according to qualifications and experience. Academic salary scales are currently: Lecturer NZ\$21 660-425 684, Senior Lecturer NZ\$27 088-334 387. Under exceptional circumstances the post may be filled at Senior Lecturer level.

Travel and removal expenses are reimbursed up to specified limits. Government Superannuation is available. Initial enquiries may be made to Professor J. G. H. White, Head of the Plant Science Department, at Lincoln College, Canterbury.

Conditions of Appointment containing further details of this position are available from the Secretary General, The Association of Commonwealth Universities (Appts), 36 Gordon Square, London WC1H 0PF, or from the Registrar, Lincoln College, Canterbury, New Zealand, with whom applications close on 22 May, 1985. Please quote Vacancy No 85/16.

### UNIVERSITY OF EXETER

#### Department of Chemistry POSTDOCTORAL RESEARCH ASSISTANT

Applications are invited for an SERC Postdoctoral Research Assistant for a period of two years from 1 October, 1985. The appointee will investigate the fluxional properties of organometallic complexes using one- and two-dimensional spin polarisation transfer n.m.r. techniques. Work will be carried out in collaboration with Professor E. W. Abel and Dr K. G. Orrell and will concern the study of carbonyl exchange and its relationship to other fluxional processes in transition metal complexes. Applicants should have experience in modern FT n.m.r. techniques applied to inorganic or organometallic compounds. Starting salary will be within the range £7520-£7980 pa + USS.

Applications, including cv and names of two referees, should be sent as soon as possible to: Dr K. G. Orrell, Department of Chemistry, The University, Exeter EX4 4QD.

### THE LONDON HOSPITAL MEDICAL COLLEGE (University of London)

#### LABORATORY SCIENTIFIC OFFICER IN BIOCHEMISTRY

There is an immediate vacancy for a Laboratory Scientific Officer in the Department of Biochemistry. Major duties will include assistance in the practical classroom. Applicants should possess an HNC or equivalent in an appropriate discipline. Salary range £5738-£8096 plus £1084 London Weighting.

Please contact the Assistant Secretary (Personnel) Tel 01-377-8800, Ext 12/13 at The London Hospital Medical College, Turner Street, London E1 2AT for further details and an application form. (Closing date within 21 days of this advertisement).

### PRINTING INK DEVELOPMENT

Due to an expansion, a vacancy exists for a Graduate Development Chemist. Much of the project work involves a highly specialised sector of the printing industry, although a broad previous experience of paste inks is of some relevance. This senior post reports to the Technical Director, and the experience and maturity of the appointee is likely to be reflected in an age of 30 plus. Location is S.E. England. Please reply in confidence to Box No. D669.

### SUMMER TERN WARDENS

Temporary posts to Warden and Census birds on two wet Solent Nature Reserves. Applicants 23+. Write with SAE to Hants & Avon Naturalists' Trust, 8 Market Place, Romsey, Hants SO5 8NB Closing date 22 April.

### GET THAT JOB!

A professionally prepared cv could secure you that vital interview. Details from Dane Services 0721-66002.

### PHYSICS

#### Wellington College, Berkshire

A vacancy will exist in September, 1985, for a well-qualified PHYSICIST

to teach at all levels throughout the school. The successful applicant will be someone who is anxious to play a full part in the life of the community.

Applications, together with cv and the names of two referees to: The Master, Wellington College, Crowthorne, Berks, as soon as possible.

# Technical Officer

## synthetic organic chemistry agrochemicals research

attractive salary

Ongar, Essex

The Agrochemicals operation of May & Baker – based at Ongar in Essex – is expanding its original research activities in its role as one of two centres of excellence for the Rhône-Poulenc Group, of which it forms a strategic element.

The Group has recently committed nearly £7 million to new R & D facilities and is now one of the top 6 agrochemical companies in the world, with the Ongar site having sole responsibility for insecticide synthesis for the Group.

As an experienced Technical Officer, you will join and play an active part in an established research team and be responsible for the design and synthesis of novel compounds within specified programmes. Your depth of experience will be seen as a valuable asset to our continuing research programme.

In your late 20's/early 30's, you should be educated to HNC level – probably graduateship of the Royal

Society of Chemistry – and have proven long term practical experience. Ideally you will have specialist skills in the synthesis of agrochemicals.

We offer an excellent salary, dependent on your experience and ability. Benefits are those appropriate to a major group and will include assistance with relocation expenses where applicable.

**For an application form please telephone  
01-730 7584/7749 (24 hour Ansafone)  
quoting ref NS/189.**

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London SW1W 0AW.



**M&B May & Baker**



### ASTON UNIVERSITY

## DEPARTMENT OF CIVIL ENGINEERING AND CONSTRUCTION

Opportunities exist for engineers and scientists, who have or expect shortly to obtain good honours degrees, to pursue research leading to a PhD or MPhil. Financial support will be available from a number of sources for projects related to the department's main areas of research interest, in which it has active groups with excellent facilities and international reputations.

These are in the fields of:

**Construction Materials** (physical and chemical properties of hydrated cements, durability and protection of concrete, corrosion of metals, fire behaviour of structural materials, exploitation of waste materials, soil freezing phenomena, computer simulation of mechanics of particulate materials).

**Systems and Remote Sensing** (software development for satellite image processing and analysis, pattern recognition, artificial intelligence, geo-data-bases, application of remote sensing to earth and environmental sciences, to land and water resources, and to civil engineering and hydrology).

There may also be opportunities for individual research in the areas of structural design, design and construction, transport planning and construction management.

Further information may be obtained from:

Dr C. L. Page, Department of Civil Engineering and Construction, Aston University, Aston Triangle, Birmingham B4 7ET.  
Tel. No. 021-359 3611.



**Battelle** Geneva Research Centres

is seeking for its Industrial Technology Centre a

## POLYMER ENGINEER

to develop new activities in polymer applications.

Candidates should have a university degree in the field of Polymer Science and Technology, Materials Science or Polymer Engineering and an ability to identify, promote and lead research projects.

Industrial experience would be an advantage, and the following technical expertise will be decisive in the choice of candidate:

- Fabrication of end products, including composites, particularly by new technologies (pultrusion, R-RIM, etc.).
- Knowledge of relationship between product characteristics and processing parameters.
- Capacity to identify market opportunities for new processes and products.

This position offers:

- Good salary and benefits.
- International and multidisciplinary work environment.
- Wide contacts with industry.
- World-wide travel opportunities.

Please address applications, including cv, photograph and salary requirements to: The Personnel Manager, Battelle, 7 route de Drize, CH-1227 Carouge/Geneva, Switzerland.

# Medical Physics & Bio-Engineering Opportunities Saudi Arabia

General Arabian Medical and Allied Services Limited (GAMA) is the Hospital Management Company providing consultancy services to the prestigious Riyadh Al-Kharj Hospital Programme in Saudi Arabia. The Programme includes the 620-bed Armed Forces Hospital in Riyadh, a 61-bed satellite Hospital 50 miles to the South at Al-Kharj and a number of peripheral clinics. These modern, well equipped Hospitals provide sophisticated medical services to the employees of the Armed Forces and their dependants.

The department of Medical Physics and Bio-Engineering at the Riyadh Armed Forces Hospital is the largest such department in the Middle East with a mainly British staff numbering nearly 50. The department offers excellent facilities to allow well qualified professionals to undertake a wide range of clinical support and development activities in a busy, modern department. Senior staff may have the opportunity to travel to other parts of the Kingdom as the department is often called upon to provide consultancy services to other Hospitals and projects throughout Saudi Arabia.

The following senior opportunities now exist within the department:

## CONSULTANT PHYSICIST Bio-Engineering Section (ref. 6051)

## CONSULTANT PHYSICIST Nuclear Medicine & Ultra Sound Section (ref. 6083) £52,330 p.a. TAX FREE

Candidates for the above posts must have a minimum qualification of M.Sc. (Ph.D. preferred) and approximately 10 years' relevant experience.

## SENIOR TECHNICIAN Bio-Engineering (ref. 6067) £25,700 p.a. TAX FREE

Candidates for this post should be qualified to HTEC or equivalent level and should have a minimum of 5 years' relevant experience.

### BENEFITS

These married or single status contracts are normally offered for a two-year initial term and carry benefits which include: free fully-furnished accommodation; four weeks' leave after every six months service; free air fares (including leave flights); free health care and extensive recreational facilities. These benefits also apply to dependants of married candidates.

The sterling salaries quoted are based on 4.1 Saudi Riyals = £1 and include a bonus of one month's salary for each year of satisfactory service payable at the end of your contract.

Please write with a comprehensive curriculum vitae or telephone for an application form to:

Susan Grice,  
**GAMA INTERNATIONAL LIMITED**  
6 Duke of York Street, London SW1Y 6LA.  
Telephone: 01-839 6843.



## CHEMISTRY GRADUATES ARE YOU UNEMPLOYED OR REQUIRE TEMPORARY WORK?

Contactasol Ltd, a manufacturer of sterile ophthalmic products, require temporary day and shift chemists to work in Quality Control Department analysing raw materials and products. Initial period of employment of three months. Good rates of pay. If interested, please write with CV or telephone immediately.

Mr C. Skiller,  
Chemistry Section Head,  
CONTACTASOL LTD,  
Unit 2, Leigh Close,  
161, Kingston Road,  
New Malden, Surrey.  
Tel: 01-949 5616.

## ST. BARTHOLOMEW'S HOSPITAL

West Smithfield, London EC1A 7BE. 01-600 9000

### COMPUTER PROGRAMMERS

We are seeking programmers with relevant degrees to work with the existing Computing Unit team on an expanding developing programme.

The successful applicants will be expected to undertake a range of responsibilities for the maintenance and running of existing systems as well as new development work. They must be experienced in FORTRAN and familiar with the use of database management systems. A knowledge of microcomputers would be an advantage.

Salary: (Scientific Officer Scale) £7020 - £9808 p.a. inc.

For job description and application form please contact the Personnel Department on 01 600 9000 ext 3188 quoting ref. AB/19.

THE CITY AND HACKNEY HEALTH AUTHORITY

## UNIVERSITY OF LIVERPOOL

### School of Chemistry

Applications are invited for the following three SERC awards from candidates who have obtained, or expect to obtain a first or upper second class honours degree in chemistry or a related subject.

**METALLOPORPHYRINS AS CONFORMATIONAL PROBES**  
This project involves the development of metalloporphyrins as NMR probes of molecular structure and complexation.

**MOLECULAR MODELLING STUDIES OF BIOLOGICAL SYSTEMS**

This project is with Roche Products and involves computer modelling and NMR studies of the electrostatic interactions in metalloporphyrins, nucleotides and drugs.

**COMPUTER MODELLING AND NMR STUDIES OF ZEOLITES**  
The project is with ICI (New Science Group) and involves computer modelling of zeolite cavities and NMR studies of the zeolite substrates.

Informal enquiries may be made to Dr R. J. Abraham.

All applications should be made to The Registrar, The University, PO Box 147, Liverpool L69 3BX, as soon as possible.

Quote Ref: RV/232/NS.

## ROTHAMSTED EXPERIMENTAL STATION

Harpenden, Herts AL5 2JQ

### PHYSICIST/ELECTRICAL ENGINEER

required to join a research team investigating radar to monitor airborne pests. The appointment will be for a maximum of three years. Duties will be to measure the radar cross section of insects, to investigate their microwave scattering properties and devise a radar system key.

Applicants should have a degree or HNC in Physics or Electrical/Electronic engineering with appropriate post-graduate experience for appointment at the higher grade. Potential 1985 graduates invited to apply.

Salary: Higher Scientific Officer on scale £7435-£10 635; Scientific Officer on scale £5009-£8153. Non-contributory superannuation.

Applications to The Secretary quoting Ref 576 and giving the names of two referees by 26 April. Further details on request.

We are an equal opportunities employer.

## UNIVERSITY OF ABERDEEN

### Department of Anatomy

#### RESEARCH ASSISTANT

Applications are invited for a position as Research Assistant to work on a project investigating the morphological effects of undernutrition during early life on the development of the rat cerebellum. This will involve both light and electron microscopical techniques. The project is funded by the Wellcome Trust and is for a period of 29 months. The successful candidate will be expected to register for an MSc degree. Applicants must have or expect to obtain an upper second class degree in a relevant Biological Science.

Initial salary on the minimum point on the IB scale £6800-£8920 for Research and Analogous Staff.

Application forms are available from The Secretary, The University, Aberdeen, with whom applications (two copies) should be lodged by 26 April, 1985.



# Technician for Tree Research

Shell Research Limited has a vacancy for a Technician to work at their Research Centre near Sittingbourne, Kent.

The Plant Cell and Molecular Biology Group is seeking an experienced technician to join a team developing propagation methods for forest trees.

The person appointed will be primarily involved with propagation and care of a number of exotic tree species in the glasshouse. The work will also involve multiplication and rooting of plantlets (using plant tissue culture techniques) and their establishment in soil. The job may require working visits overseas.

The ideal candidate would have several years' experience in the propagation of woody species, plus some experience with plant tissue culture techniques. A formal horticultural or related qualification would be an advantage.

The starting salary will be competitive, in line with your qualifications and experience. You will work in well equipped laboratories situated in a 500 acre farmland site, and enjoy excellent facilities for sports and social activities.

Please write for an application form quoting reference No. 840035 to: Mrs. M. Newton, Personnel Division (PNS/2), Shell Research Limited, Sittingbourne Research Centre, Sittingbourne, Kent ME9 8AG. *Closing date for applications is April 25th, 1985.*



## HEAD OF MICROBIOLOGY DEPARTMENT

Due to an internal transfer a vacancy has arisen for an experienced research microbiologist to manage the research and service activities of a large microbiology department.

Applicants should have received formal training in microbiology at least to degree level, have substantial research experience in food preservation and processing and a good up-to-date theoretical and practical knowledge of microbial physiology or biochemistry. Preference will be given to candidates with management experience.

Salary will be dependent on age, qualifications and previous experience.

Application forms are available from the Secretary-General, The Campden Food Preservation Research Association, Chipping Campden, Glos. GL55 6LD.

## CROYDON HEALTH AUTHORITY Mayday Hospital AUDIOLOGICAL SCIENTIST

To continue development of the department while undertaking practical procedures within the Clinic.

Post Probations Salary Scale: £6813/£7525 pa plus £648 London Weighting.

For application form and/or to arrange informal visit, please contact Unit Personnel Department, Mayday Hospital, Tel 01-684 6999, Ext 3721/3530.

## BIOLOGIST WITH COMPUTING KNOWLEDGE

Rohm & Haas, a major US research based chemical company, has an exciting and unusual vacancy for a Biologist with some knowledge of computer science.

The job will be office based at the Company's European headquarters in Holborn and will entail editing the technical content of material received from the field, market research, and running the PC database programs system associated with this.

The person chosen will have a degree in Biological Sciences combined with data processing and will probably be aged 22-25. This is an excellent opportunity for a hard-working and self motivated young person to join the Company's highly successful agricultural team.

*Please write, enclosing a brief CV, for an application form to:*

**Mrs Ingrid Francis, Personnel Officer**

**ROHM AND HAAS (UK) LIMITED.**

LENNIG HOUSE, 2 MASON'S AVENUE,  
CROYDON, CR9 3NB, ENGLAND.  
TELEPHONE 01-888 8844



## IMPERIAL COLLEGE Department of Physics POSTDOCTORAL RESEARCH ASSISTANT

required with experience in plasma physics, laser physics, or atomic spectroscopy to join a group working on a promising new method for accelerating particles to ultra high energies in a plasma by a laser beat wave. The work is based on the high power Vulcan laser at the Rutherford-Appleton Laboratory. The three year SERC funded appointment commences on 1 May, 1985 with a salary in the range £8753-£10153 including London Allowance.

Enquiries or applications (cv, publications list, and two referees) to Professor M. G. Haines, The Blackett Laboratory, Imperial College, London SW7 2BZ (01-589 5111, Ext 6871) as soon as possible.

## BREWING MICROBIOLOGIST

Charles Wells Ltd, a successful independent company requires a senior technician for the microbiology section of their modern brewery. The successful applicant will report directly to the Chief Chemist as well as liaising closely with other senior managers.

Applicants must have HNC Microbiology or equivalent. Salary will depend on experience and qualifications. There are 20 days annual leave plus generous fringe benefits.

Apply in writing with full personal details including current salary to:  
J. C. Chinnamond BSc. C. Biol. MI Biol  
Chief Chemist  
Charles Wells Ltd  
The Brewery  
Haverstock Street  
Bedford MK40 4LU.

# SCIENTIFIC SUPPORT OPPORTUNITIES

## ADAS—Agricultural Science Service

Fisheries and Farming

## NUTRITION CHEMIST

Cardiff

... to provide scientific support for Nutrition Chemistry Advisers, including sampling and examination of animal

feeds and calculation of results; recording livestock performance, statistical analysis and report writing.

## SOIL SCIENTISTS

Cambridge, Leeds and Newcastle

... to provide scientific support for Soil Science Advisers, including carrying out field investigations, statistical analyses, surveys, and the physical examination of soils.

You should have a degree, HND or equivalent in an

appropriate subject. Agricultural or other related experience would be an advantage. A full valid UK driving licence is essential.

Appointment as Scientific Officer. Ref: SB/38/AL

## Fisheries Research Directorate, Lowestoft

There are currently two opportunities for experienced fisheries scientists to join a team responsible for the management of

fish stocks in the North Sea and adjacent waters. They are as follows:

## BIOLOGIST/MATHEMATICIAN

Shellfish

You will be responsible for assessments of lobster, crab and shrimp stocks, using current fishery and shellfishery models. You will also be expected to develop and lead new research

on population dynamics, and on the nature and impact of the trap fisheries, which will lead to the exploration of new fisheries management strategies.

## BIOLOGIST

Freshwater and Coastal Species

You will initiate and carry out research on aspects of biology, assessment and management of fish stocks. Initially you will investigate eel stocks and fisheries and also coastal fisheries using gill nets, possibly moving to studies of salmonid stock enhancement.

Both appointments carry a commitment to work at sea on the Ministry's research vessels and on vessels chartered by the Ministry.

You should have a good honours degree in a biological science and have at least 2 years postgraduate research experience in the appropriate field. For the Shellfish post, your degree should have a strong component of biomathematics and ecology; graduates in mathematics or physics with an aptitude for ecological work may apply.

Appointment as Higher Scientific Officer. Ref: SB/91/AD.

**Salaries:** Scientific Officer £5905 – £8150, Higher Scientific Officer £7435 – £10,035. Starting salary according to qualifications and experience.

For further details and an application form (to be returned by 3 May 1985) write to Civil Service Commission, Alencon Link,

Basingstoke, Hants, RG21 1JB, or telephone Basingstoke (0256) 468551 (answering service operates outside office hours).

Please quote appropriate reference.

The Civil Service is an equal opportunity employer

Ministry of Agriculture, Fisheries and Food

### UNIVERSITY OF EDINBURGH

#### DEPARTMENTS OF ARTIFICIAL INTELLIGENCE AND COMPUTER SCIENCE

#### ONE LECTURER

Applications are invited for a joint post of Lecturer in the Departments of Computer Science and Artificial Intelligence. The appointee will teach in both Departments and will conduct research into mechanised reasoning. Current research interests include: Logic Programming and the automation of mathematical reasoning in the Artificial Intelligence Department; the semantics of computation, programming logics and machine-assisted reasoning in the Computer Science Department.

#### Department of Computer Science

#### Two Lecturers, One Computing Officer

Applications are invited for three posts in the Department of Computer Science.

One Lecturer will specialise in VLSI Design, particularly its application to highly concurrent systems. He/she will join an active group of VLSI workers engaged in research into novel design tools, silicon compilation and formal verification systems.

The second Lecturer will probably have research interests in computer systems and/or communications but strong candidates of any specialisation within computer science are invited to apply. Funds for further posts are expected.

The Computing Officer will undertake a small amount of teaching, but is principally required to design, construct and maintain the software and hardware required to support the research and teaching programmes of the Department. Salary Scale (under review):

Lecturer £7520-£14 925

Computing Officer £6600-£12 150

with placement according to age, qualifications and experience.

The mechanised reasoning and the VLSI design posts are funded under the UGC Information Technology initiative, a person appointed in the UK may not be appointed to either of these two posts.

Applications by letter, including a cv and the names of three referees, should be sent to: The Secretary, University of Edinburgh, Old College, South Bridge, Edinburgh EH8 9YL, from whom further particulars may be obtained. Closing date: 3 May, 1985. Late applications might be considered.

For the joint AI/CS post, send two copies of the application and quote Ref IT2. For the other posts, send one copy and quote Ref IT3.

### DURHAM UNIVERSITY

#### Department of Physics

#### ASTRONOMICAL SPECTROSCOPY

Applications are invited for a POSTDOCTORAL RESEARCH ASSISTANT tenable for two or three years, starting as soon as possible after 1 June, 1985. The successful applicant will join a team developing and commissioning a CCD detector system to be used with the multi-object fibre spectrograph on the United Kingdom Schmidt Telescope. Applicants should have a knowledge of electronics as well as research interests in observational astronomy.

Initial salary up to £8920 pa on Range 1A plus superannuation.

Applications (three copies), naming three referees, should be sent by 30 April, 1985 to the Registrar, Science Laboratories, South Road, Durham DH1 1LE, from whom further particulars may be obtained.

# UNIPATH

Unipath, a growing force in medical diagnostics is seeking the following graduates to join their expanding Research and Development group.

## CHEMISTS AND BIOCHEMISTS

with experience in protein chemistry are required to work in teams on the immobilisation and chemical modification of proteins.

## BIOCHEMISTS

experienced in clinical biochemistry are required to work on the development of novel diagnostic test systems.

These exciting opportunities will ideally suit young, self-motivated graduates with good honours degrees (or equivalent) in chemistry, biochemistry or related disciplines. Candidates should be capable of contributing creative ideas based on sound theoretical knowledge and practical experience gained in an industrial environment.

As part of a major multi national company, UNIPATH is able to offer excellent career prospects, working conditions and benefits including generous holiday entitlement, sports and social facilities, sickness scheme and superannuation.

Starting salaries will be in the range £7500-£9000 per annum depending on age, qualifications and experience.

If interested please write to, or telephone:

**Mrs Judith Monico**  
Personnel Manager  
Unipath Limited  
Norse Road, Bedford MK41 0QG  
Tel: (0234) 47161



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## SPEECH RECOGNITION RESEARCH

Development Scientist required for research into Advanced Speech Pattern Processing Algorithms in connection with a Speech Input/Output implementation sponsored by the Alvey Directorate.

Sindex Speech Technology Ltd invite applications from suitably qualified persons to work within the Speech Recognition Group. The successful candidate, after satisfactory indications of performance during the initial period of research, would be offered the future leadership of the Group. The first year of the project will be carried out in the Malvern area and further development continued in London or Cambridge.

Ideally the candidate would have experience in either Statistical Modelling, Scientific Computing or Speech Recognition techniques. Post Doctorate or relevant industrial experience would be an advantage but not essential.

Remuneration will be commensurate with qualifications and experience. Personal achievement is respected and appropriately rewarded.

Applications giving details of age, qualifications and experience should be sent as soon as possible to:-

**Dr Paul Thompson, Sindex Speech Technology Ltd,**  
60 Albert Court, Prince Consort Road, London  
SW1 2BH.

## UNIVERSITY OF EDINBURGH Edinburgh School of Agriculture Lecturer in Animal Biochemistry and Ruminant Nutrition

Applications are invited for the post of Lecturer in Animal Biochemistry and Ruminant Nutrition.

Applicants should have a formal grounding in agricultural biochemistry and nutrition, or related disciplines, and have relevant postgraduate experience. The appointed person will be expected to pursue an active research programme, in addition to the normal range of university teaching duties. Initially, the post will be for a three-year period.

Further details from and applications to: The Secretary to the University, University of Edinburgh, Old College, South Bridge, Edinburgh EH8 9YL, not later than 5 May, 1985.

Please quote Reference No 1183.

## MEDICAL RESEARCH COUNCIL

### ADMINISTRATIVE APPOINTMENT FOR A SCIENTIST

Science graduates interested in a career in research administration—giving opportunities to be involved with the latest developments in medicine and biology—are invited to apply for appointment as a Scientific Administrative Officer in the Council's London office. The Council has an annual budget of some £120 million and is the main government agency for promoting medical research.

The successful candidate is likely to be aged between 28-40, with some experience both of biomedical research at a postdoctoral level and of administration, and with broadly informed interest in science and medicine. The initial posting will probably be as Scientific Secretary of a Grants Committee and, as such, will include responsibility for day-to-day liaison between the Council and the research community in Universities, Medical Schools, Hospitals and Research Institutes.

The Council's headquarters staff are appointed on terms and conditions analogous to those of the Civil Service. Subject to satisfactory completion of a two-year probationary period, the appointment will be permanent. The salary scale (Senior Scientific Officer grade) offered is £9328 to £12060 plus £1300 London Weighting and a contributory pension scheme with pay supplement. Salary rates are currently under review.

Further information and application forms may be obtained by writing or telephoning to Miss Margaret Gale, Medical Research Council, 20 Park Crescent, London W1N 4AL (Tel: 01-636 5422, Ext 237); the closing date for applications is 3 May, 1985.

## SCHOOL OF MEDICINE UNIVERSITY COLLEGE LONDON Department of Paediatrics RESEARCH TECHNICIAN (GRADE 3)

required to assist with a project on the transport and neurotoxicity of bilirubin in the brain of the newborn. The two year appointment is funded by Birthright. Salary £6851-£7155 inc L.W. Experience in physiological research and biochemical techniques—liquid scintillation counting, spectrophotometry, dialysis etc, would be an advantage, but not essential.

Application with cv and names of two referees to Dr N. K. Ives, Department of Paediatrics, School of Medicine, University College London, The Rayne Institute, University Street, London WC1E 6JJ.

## RIVERSIDE HEALTH AUTHORITY Senior Medical Laboratory SCIENTIFIC OFFICER HISTOPATHOLOGY

This post is required for the establishment of a Neuro-Histology service within the Histopathology Department at Charing Cross Hospital and will provide an excellent opportunity for someone wishing to specialise without losing contact with routine work. Applicants must be State Registered and Fellows of the IMLA.

For further information, contact Mr K. R. James, SCMLSO on (01) 748 2040, Ext 2738.

Application forms and job description may be obtained from Mr W. Finlayson, District Personnel Department, on Ext 2897. Closing date: 26 April, 1985.

## Scientists

Why not enter Sales?

Salaries £5000-£8000 Basic  
+ Car + Bonus

If you want a career with a future, where you are rewarded according to your effort then consider selling. We have vacancies with major companies in pharmaceuticals, diagnostics and medical/scientific equipment throughout the UK.

For a local interview to discuss an exciting future ring Sutcliffe Selection 0256 55955, (24 hours) 46/48 Essex Road, Basingstoke, RG21 1TB.

**Sutcliffe  
Selection**

## UNIVERSITY OF READING SOIL MICROBIOLOGIST

Applications are invited for the post of Research Fellow at post-doctorate level to investigate the bacterial/fungal/protozoan succession during the decomposition of animal manures in soil. This investigation will be linked to work on nitrogen transformations. Applicants should have wide practical experience in microbiology. The project is financed by AFRC and is expected to last for a fixed period of four years. Starting Salary £7520 pa. US\$ superannuation. Apply quoting Ref R13A for application form and further particulars to Personnel Officer, University of Reading, Whiteknights, PO Box 217, Reading, RG6 2AH. Tel (0734) 812123, Ext 233. Closing date 10 May, 1985.

## UNIVERSITY OF EXETER Department of Chemistry

### POSTDOCTORAL RESEARCH ASSISTANT

Applications are invited for an SERC supported Postdoctoral Research Assistant for a period of two years to commence 1 October, 1985. Candidates will work in the field of metal complexes of electron-rich heterocyclic systems of phosphorus, arsenic, antimony, sulphur and selenium, in collaboration with Prof R. W. Abel.

Starting salary will be in the range £7520-£7980 pa + US\$ benefits.

Applications, including cv and names of two referees, should be sent to Prof R. W. Abel, Department of Chemistry, The University, Exeter EX4 4QD, as soon as possible.

# Technical Officer

*Microbiology section*

*Nr Uxbridge, Middlesex*

*c. £7,000*

We are Glaxo Animal Health Limited, responsible for the Group's veterinary and animal healthcare business on a worldwide scale.

We now have an excellent opportunity for a young biological science graduate to join the microbiological team within our Research & Development Department.

You will work as a Technical Officer in a laboratory concerned with the development and evaluation of antibacterial preparations for use in veterinary medicines. Responsibilities will include routine bio assays, bacterial isolation, identification, and sensitivity testing, and other standard microbiological tests, as well as maintaining records to GLP standards. There will be opportunities to use and become familiar with new analytical techniques as they are introduced.

The company, situated in rural surroundings, but only 5 minutes from the centre of Uxbridge, offers an attractive salary plus Outer London Allowance and is backed by a generous range of benefits including guaranteed annual bonus, a non-contributory pension scheme, 22 days' holiday and staff canteen.

For an application form, please contact Mrs M A Model, Company Personnel Officer, Glaxo Animal Health Limited, Breakspear Road South, Harefield, Middlesex UB9 6LS. Tel: Ruislip (089 56) 30266.

**Glaxo** *Animal Health Limited*

BP is Britain's largest and one of the world's most successful companies. BP Research Centre provides Group companies with comprehensive research and development facilities for the support of existing business areas and for the exploitation of new businesses.

## Assistant Technologist

**"new liquid fuels sources development"**

An opportunity has arisen for an assistant to work with a small group of graduate technologists investigating fundamental surface properties of a number of novel carbonaceous adsorbents and catalysts. The work of the Group is relevant to some of the vital problems in development of new sources of liquid fuels and their efficient utilisation in a number of practical systems and you would be using sophisticated and advanced techniques for the study of properties of solid surfaces and adsorbed substances.

Qualified to minimum Higher TEC or HNC in Physics or Chemistry, you should have at least two years' practical laboratory experience of surface chemistry or physics.

An attractive remuneration package includes non-contributory pension scheme, subsidised restaurant and extensive on-site sports facilities.

Please write or telephone for an application form, quoting reference **SR 3604**, to: Anne Sheppard, BP Research Centre, Chertsey Road, Sunbury-on-Thames, Middlesex TW16 7LN. Tel: Sunbury-on-Thames (09327) 62028.

*BP is an equal opportunity employer.*

**BP** **Research**  
**SUNBURY-ON-THAMES**

**ROTHAMSTED EXPERIMENTAL STATION,**  
Harpden, Herts AL5 2JQ  
Plant Pathology Department

**PLANT VIROLOGIST (REF 589)**  
required to work on the identification, purification, characterisation and diagnosis of strains of barley yellow dwarf virus affecting cereal crops in developing countries, especially those of Central and South America. The person appointed will be required to develop diagnostic methods appropriate for use in developing countries and to have an interest in aphid transmission and epidemiology. An important part of the work is the transfer of the techniques developed to local staff. The work will be based at Rothamsted but a period of up to six months may be spent overseas. This post is for a maximum of three years supported by the Overseas Development Administration.

**MICROBIOLOGIST (REF 590)**  
required to study the detection of airborne antigens associated with occupational respiratory disease. Duties will include the testing of sampling methods, sampling at sites where respiratory allergy has occurred and correlation of the incidence of airborne microorganisms and other antigens with respiratory disease. The post is for a maximum of three years, funded by the Health & Safety Executive.

Qualifications: 1st or Upper 2nd Class Honours degree in a relevant discipline (for Post Ref 589—Biology, Plant Pathology, Biochemistry; for Post Ref 590—Microbiology and a knowledge of immunology, biochemistry and statistics will be an advantage) and at least two years postgraduate experience.

Appointments in the grade of Higher Scientific Officer (£7435-£10,039). Non-Contributory superannuation.

Application Form available from The Secretary, quoting the appropriate Reference No(s). Further details on request. Closing date 3 May 1985.

We are an equal opportunities employer.

### CHARING CROSS HOSPITAL PHYSIOLOGICAL MEASUREMENT TECHNICIAN LUNG FUNCTION

Required by the Cardiopulmonary Unit to perform a variety of routine and non-routine tests including lung function tests, exercise tests and blood gas analysis. Participation in research projects will be encouraged. Experience in lung function testing and blood gas analysis is required and all candidates must have followed a two year course of training and possess an ONC in Physiological Measurement or an OTEC in Medical Physics and Physiological Measurement, or an equivalent qualification.

Salary scale: £5909 pa-£7271 pa inclusive.

Facilities include subsidised restaurant and social club with heated swimming pool and squash courts.

An informal visit may be arranged by ringing the Lung Function Laboratory on 01 748 2040 Ext 2827.

Application form and job description available from the Unit Personnel Department, Parsons House, Charing Cross Hospital, Fulham Palace Road, Hammersmith W6 8RF. Tel 01 748 2040 Ext 2992

## EEG TECHNICIAN

### c£15,000 p.a. Tax Free + Bonus

#### Riyadh, Saudi Arabia

General Arabian Medical and Allied Services Limited (GAMA) is the Hospital Management Company providing consultancy services to the prestigious Riyadh Al-Kharr Hospital Programme in Saudi Arabia. The Programme includes the 620-bed Armed Forces Hospital in Riyadh, a 61-bed satellite Hospital 50 miles to the South at Al-Kharr and a number of peripheral clinics. These modern, well equipped Hospitals provide sophisticated medical services to the employees of the Armed Forces and their dependants.

The successful candidate would be expected to provide EEG and Evoked Potential service. Reporting to the Consultant Neurologist he/she would also be responsible for the day-to-day running of the unit, such as booking appointments for EMG's and the day-to-day care of the EMG equipment, maintaining a good filing system of all neurophysiology recordings, typing and dispatch of the reports etc.

Periodically, local technicians in training might be attached to the neurophysiology unit, in whose training the EEG Technician would be expected to participate as and when the service commitments allow.

Candidates should have a basic diploma from the British Society of Electro-encephalography and have been employed as a neurophysiology (EEG) technician for 4 years (including training periods). One year's post-qualification experience of recording EEG's and Evoked Potentials is essential.

#### BENEFITS:

This single status contract is offered on a two year renewable basis and provides: free fully-furnished accommodation; four weeks' leave for every 6 months of service; free flights (including leave flights) and a two months' salary bonus on satisfactory completion of contract. Salaries are paid in Saudi Riyals and the sterling salary quoted is calculated at the current exchange rate of 4.1 Saudi Riyals = £1.

Please write with a comprehensive curriculum vitae or telephone for an application form, quoting ref. 6013, to:

Susan Grice,  
GAMA INTERNATIONAL LTD.,  
6 Duke of York Street, London SW1Y 6LA.  
Telephone: 01-839 6843.



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#### YES?

Then you are just what we are looking for.

We are a young expanding company specialising in Process Analytical Instrumentation for the Oil and Gas Industry, based in Crayford, Kent.

The successful candidate for this position is likely to be aged between 25 and 45 with formal qualifications to graduate level or equivalent in Scientific/Engineer subjects.

We in return can offer the applicant the opportunity to be involved in the Design and Development of technical/scientific equipment together with the opportunity to become involved in the setting up and organisation of a new department.

An attractive remuneration package is offered, together with Company Pension Plan and Profit Share Scheme. Our hours of work are Monday to Friday, 8.30 a.m. - 5.00 p.m. If you feel that you can offer the above, then please ring Mrs B. A. Griffiths on Crayford 528125 or write in confidence enclosing a curriculum vitae to:

Fluid Data (UK) Limited, 20 Bourne Industrial Park, Bourne Road, Crayford, Kent DA1 4BZ.

## THE MEDICAL COLLEGE OF ST BARTHOLOMEW'S HOSPITAL DEPARTMENT OF CHEMICAL PATHOLOGY

### SYNTHETIC ORGANIC CHEMIST

Required to join a group developing non-radioactive immunoassays for the measurement of drug levels. Applicants should have a good Honours degree with some experience of synthetic chemistry or an MSc.

Appointment for one year initially, available immediately. Salary £7643 pa to £9395 pa inclusive according to previous experience. Please forward detailed curriculum vitae to:

Dr G. Gallacher, Department of Chemical Pathology (Research),  
St Bartholomew's Hospital,  
West Smithfield, London EC1

Closing date: 26 April, 1985.

## BRISTOL POLYTECHNIC SCIENCE DEPARTMENT

Applications are invited for the following posts, duties to commence on 1 September, 1985.

### Lecturer II/Senior Lecturer in Analytical Chemistry (two posts)

Ref No L/1

Candidates should possess high academic qualifications and research or industrial experience in analytical chemistry. Both posts involve teaching in the theory and application of analytical science and the development and operation of a Consultancy Service recently established in the Department. The successful applicant will be expected to develop new links with industry.

For one post candidates should have a particular interest in teaching in the biological science courses and for the other, electrochemistry in the physical science courses.

### Lecturer II/Senior Lecturer in Biochemical Engineering

Ref No L/2

Candidates should be graduates in a relevant subject who have research, industrial and/or teaching experience.

The successful applicant will teach on Degree, BTEC and GRSC courses and will be expected to contribute to the further development of biotechnology in the Department by initiating an active research programme and participating in curriculum developments.

### Lecturer II/Senior Lecturer in Scientific Instrumentation/Physics

Ref No L/3

The successful applicant will be expected to lecture in aspects of Instrumentation, Electronics, Microprocessors and the General Physics relating to Scientific Instrumentation up to and including Honours Degree level.

Salary Scale LII £7548-£11 175 (bar)-£12 099 per annum  
SL £11 175-£13 128 (bar)-£14 061 per annum

The appointment will be made on the appropriate scale according to relevant previous service/experience. (Progression from the LI scale to the SL scale is in accordance with the provisions of the Burnham Further Education Report.) For further details and an application form, to be returned by 22 April, 1985, please contact the Personnel Office, Bristol Polytechnic, Coldharbour Lane, Frenchay, Bristol or ring Bristol 656261, Ext 216 or 217.

## WEST LAMBETH AUTHORITY ST THOMAS' HOSPITAL

Chemical Pathology Department (Supra Regional Assay Laboratory)

(JUNIOR/BASIC GRADE)

### MEDICAL LABORATORY SCIENTIFIC OFFICER

A vacancy exists in the Supra Regional Assay Laboratory which performs a number of routine protein and steroid-hormone assays. Experience in redoximmunoassay techniques would be an advantage.

Opportunity and encouragement given for relevant further studies. The laboratories are modern and well equipped, and the hospital is conveniently situated close to both main line and underground stations, and is on many bus routes.

Whitley Council salary and conditions of service are applicable.

Applicants to send two references to:

Dr M. Wheeler,  
Chemical Pathology Department  
Supra Regional Assay Laboratory  
St Thomas' Hospital, London SE1 7EH

# Reproductive Toxicology Section Head

Beecham Pharmaceuticals is a major British Company involved in the research and development of ethical medicines. Evaluating their safety is an essential element.

We are now seeking to recruit an experienced reproductive toxicologist to head a small team concerned with the design, conduct, evaluation and reporting of both routine and non-routine reproductive toxicity studies.

The successful applicant will be able to demonstrate good organisational skills. In particular he or she needs to establish clear priorities and co-ordinate the work of the section with that of other areas, particularly those responsible for necropsy and foetal examinations. An ability to supervise

and motivate staff, contributing ideas where necessary, is obviously also required.

Our site at Stock in Essex is conveniently located in a semi-rural environment, within easy reach of Chelmsford and neighbouring towns which together offer a wide range of housing and other facilities.

For the right candidate, we can offer an attractive salary, pleasant working conditions, and the usual fringe benefits associated with a large and profitable company.

For an application form, please write to the Senior Personnel Officer, Beecham Pharmaceuticals Research Division, Honeyput Lane, Stock, Essex CM4 9PE, quoting reference 3/85.

## Beecham Pharmaceuticals

# Clinical Chemist

Smith Kline & French undertake intensive and innovative research and development in the field of ethical pharmaceuticals. Our laboratories and equipment are among the most advanced in the field.

We have a vacancy in our Pathology Department for a Clinical Chemist to undertake the routine and special analysis of biological samples from studies which form part of the safety evaluation of novel compounds. The section uses a variety of techniques including radioimmuno assay and has modern equipment with on line computer systems.

A Degree in Biochemistry or Applied Biology, or an HTEC in Medical Laboratory Science is required preferably with at least 12 months' experience of relevant laboratory work.

We pay competitive salaries and provide a full range of benefits.

Please send a detailed CV outlining your qualifications and experience quoting reference number NS/118/JW to John Ward, Personnel Officer, Smith Kline & French Research Limited, The Frythe, Welwyn, Herts AL6 9AR.



## UNIVERSITY OF CAMBRIDGE

Department of Chemical Engineering

### 'NEW BLOOD' POST

University Lecturer or University Assistant Lecturer to take part in the teaching programme of the Department and to undertake research in food processing or a related field in chemical engineering.

Applications will be considered from graduates in chemical engineering, or other branches of engineering, or in chemistry, biochemistry, or physics. Industrial experience will be an advantage. The age limit for appointment is 35, but in exceptional cases candidates just over 35 may be considered. Persons who already hold permanent appointments in a United Kingdom university are not eligible. Appointment is initially for three years with the possibility of re-appointment, for a Lecturer to retiring age, or for an Assistant Lecturer, for two years. Stipends: Lecturer £10 330-£15 930, Assistant Lecturer £7980-£9860.

Further information and application form from: Professor J. F. Davidson, Department of Chemical Engineering, Pembroke Street, Cambridge CB2 3RA. Closing date 31 May, 1985.

### PUBLIC HEALTH LABORATORY SERVICE BOARD

#### Central Public Health Laboratory

#### SENIOR GRADE BIOCHEMIST

An experienced biochemist or immunochemist, preferably with a higher degree is required to provide support to a team of microbiologists in the Division of Microbiological Reagents and Quality Control. The successful candidate should have experience in the isolation and identification of microbial antigens. The work of the team is directed towards the developments and improvement of reagents used in the diagnosis of human bacterial diseases. An interest and some knowledge of recombinant DNA techniques would be an advantage.

Current salary range of £9415 to £12 173 plus £645 outer London Weighting. NHS terms and conditions apply.

Further details may be obtained from Dr A. G. Taylor (Tel 01-200 4400, Ext 3906).

Application form and Job Description available from the Personnel Department, Central Public Health Laboratory, 61 Colindale Avenue, London NW9 5HT.

## UNIVERSITY OF LIVERPOOL

Department of Geology

### TECHNICIAN GRADE 5

In the recently established Sedimentology Laboratory, The successful applicant will be responsible for operating a range of sedimentological research techniques, assisting in training students in these techniques and maintaining the laboratory. Experience of grain-size analysis, heavy mineral separation, cathodoluminescence microscopy, impregnation and staining techniques as applied to sediments and sedimentary rocks is required.

Candidates must possess HNC or equivalent as minimum qualification but applications from graduates in Earth Sciences will also be welcome. A minimum of eight years experience is also required.

Salary within the range £6581-£7684 pa.

Application forms may be obtained from the Registrar, The University, PO Box 149, Liverpool L69 3BX.

Quote Ref: RV/224/NS.

# SHIFT ANALYST

CIBA-GEIGY AGROCHEMICALS is a fast expanding division which markets and supplies Crop Protection and Animal Health products to agricultural distributors/merchants. Increased production means that we require an additional Quality Control Analyst to be based at our modern warehouse laboratory at Whittlesford, 8 miles south of Cambridge.

Applicants will be qualified up to Degree level in Chemistry with experience of Quality Control analysis being advantageous. The job involves raw material, in-process and final product quality control analysis. The weekly rotational shifts are from 0615 - 1415, 1400 - 2200 and 0900 - 1715. A shift allowance is payable in addition to the benefits below.

Conditions of employment are consistent with the Company's international reputation and include an attractive salary, guaranteed Christmas bonus, Sports and Social Club, and relocation assistance where appropriate.

If you are interested in the above, please telephone or write for an application form to: David Parkin, Personnel Officer, CIBA-GEIGY Agrochemicals, Whittlesford, Cambridge CB2 4QT.

Telephone: Cambridge (0223) 833621.

**CIBA-GEIGY**  
Agrochemicals

# Food Microbiologist

## Aylesford, Kent

Safeway Food Stores Limited, the UK subsidiary of the world's largest international supermarket chain, has built its reputation on providing customers with top quality products.

To help maintain the high standards of quality control Safeway demand, we now need an experienced Microbiologist to run our Microbiological Laboratory at our Aylesford Distribution Centre.

You will be involved in the random sampling of all foods entering our warehouse, in particular the examination of meat, and meat products. In addition, the investigation of problems arising from these examinations will also be your responsibility.

For Microbiologists, preferably with 5 years' industrial experience, including food microbiology, we offer a competitive salary plus a full range of benefits. These include free life assurance, contributory pension, sick pay scheme and subsidised staff restaurant.

For an application form please contact:  
The Personnel Department,  
Safeway Food Stores Ltd., Stoneborough House,  
King Street, Maidstone, Kent. Tel: Maidstone 54922.

**SAFeway**

## THE UNIVERSITY OF LEEDS DEPARTMENT OF CERAMICS "NEW BLOOD" LECTURER

Applications are invited for the above post allocated under the UGC's New Blood Scheme and available from 1 September, 1985.

A good honours degree and preferably a PhD in an appropriate area (see below) are required.

The lectureship is to promote the development of ceramic components for electronic applications, particularly for electro-optic and microwave engineering. There is an established electro-ceramics research activity in the Department which is backed by good facilities, and which has active contacts both with industry and with the related interests in the Departments of Electrical and Electronic Engineering and of Physics.

Informal enquiries may be made by writing to or telephoning Dr A. J. Moulton, Department of Ceramics, University of Leeds, LS2 9JT (Tel 0532 431751, Ext 473).

The age limit for "New Blood" posts is 35 but marginal exceptions may be made.

Salary on the academic scale for Lecturers (£7520-£14 925) (under review) according to age, qualifications and experience.

Application forms and further particulars may be obtained from the Registrar, The University, Leeds LS2 9JT quoting Ref 62/17. Closing date for applications 16 May, 1985.

## UNIVERSITY OF ULSTER Faculty of Science 'NEW BLOOD' LECTURESHIP IN EXPERIMENTAL SOLID STATE PHYSICS at Coleraine

Ref: C85/58

To undertake research in the physics of low-dimensional systems, surface physics spectroscopies or low temperature (millikelvin) physics or in some other area of condensed matter physics, and to contribute to the teaching in the Physics and Electronics programmes of the Department of Physics.

Applicants should hold a good honours degree and a higher degree in Physics and should have had appropriate research experience. In accordance with the New Blood appointments scheme, applicants should normally be under the age of 35 years and should not hold permanent university appointments in the United Kingdom.

Salary will be determined by age, qualifications and experience within the range £7520-£14 925 per annum.

Further details are available from the Staffing Office, University of Ulster at Coleraine, Cromore Road, Coleraine, Co Londonderry BT52 1SA (Telephone Coleraine 4141, Ext 225) to whom applications, including a full curriculum vitae and the names and addresses of three referees, should be sent not later than 26 April, 1985.

## UNIVERSITY OF ST ANDREWS Department of Biochemistry and Microbiology

Applications are invited for a post of

### Research Assistant or Postdoctoral Fellow

tenable for up to 23 months, to work on the molecular genetics of purine catabolism in yeast. The post is tenable immediately.

Salary at appropriate point within range £6600 to £8920 per annum, plus US\$.

Applications (two copies preferably in typescript with the names of two referees, should be sent to the Establishment Officer, The University, College Gate, St Andrews, Fife, to arrive not later than 26 April, 1985.

The Royal Geographical Society is currently seeking experienced desert researchers for an interdisciplinary expedition to the Wahiba Sands in the Sultanate of Oman 4 January - 15 April 1986.

Vacancies exist for:

Sedimentary Geologist  
Developmental Anthropologist  
(Arabist)

Forester specialist in Prosopis  
Desert Plant Physiologist  
Desert Geomorphologist

These posts are unsalaried. Candidates should only apply if they have a commitment to working in Arabia and are prepared to invest considerable time both before and after the project. Please submit a full CV to: the Project Director, Oman Wahiba Sands Project, Royal Geographical Society, 1 Kensington Gore, London SW7 2AR for further details.

## DEPARTMENT OF MATHEMATICS, STATISTICS & COMPUTING

### RESEARCH ASSISTANTSHIP IN APPLIED MATHEMATICS

Ref RASM

Applications are invited for the post of Research Assistant, tenable for up to three years from 1 September, 1985.

The research programme is concerned with the development of a new brain scanning method which is particularly useful for the early detection of cerebral haemorrhage in premature babies. This work is to be undertaken jointly with staff in Physical Sciences and in collaboration with the Bio-Engineering Unit at the John Radcliffe Hospital, Oxford. The successful candidate will work on the mathematical and computational aspects of image reconstruction algorithms.

Applicants should hold, or expect to obtain, a good Honours Degree in Mathematics or related subject and have experience in computing. Candidates would normally be expected to register for a Higher Degree.

The starting salary will be on the Researcher 'A' scale (under review), £5181-£7176 per annum.

For further details and application form write to: The Postgraduate Tutor, Department of Mathematics, Statistics & Computing, Oxford Polytechnic, Headington, Oxford OX3 0BP. Closing date for applications 29 April, 1985.

# Senior Product Registration Officer

Nr Uxbridge, Middlesex c. £16,000

We are Glaxo Animal Health Limited, responsible for the Group's veterinary and animal healthcare business on a worldwide scale.

An increase in international activity has created an excellent opportunity for a Senior Product Registration Officer to become part of our dynamic young team. This key position will carry responsibility for the registration of a wide range of pharmaceutical and biological health products.

Reporting directly to the Head of Product Registration, you will possess a life science, pharmacy or veterinary degree with 3 years' experience in international regulatory affairs. A high degree of self-motivation and good communications skills are also essential to meet the demands of this challenging post. Knowledge of a foreign language would be an asset.

The company is situated in pleasant rural surroundings, only a few minutes from Uxbridge centre, and offers an attractive salary plus Outer London Allowance.

A comprehensive benefits package includes a guaranteed annual bonus, non-contributory pension scheme, 25 days' annual holiday and staff canteen.

For an application form please telephone or write to: Mrs M A Model, Company Personnel Officer, Glaxo Animal Health Limited, Breakspear Road South, Harefield, Uxbridge, Middlesex UB9 6LS. Telephone: Ruislip (089 56) 30266.

**Glaxo** Animal Health Limited

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*FBC Limited is an international company in the field of agrochemicals and livestock products, with a strong research base and certain industrial chemical interests. It has a leading position in the British market, associated companies in a number of overseas countries and an annual turnover in excess of £100 million.*

## Registration Officer with product planning responsibilities Near Cambridge

... to obtain and maintain international registration of our veterinary products and to prepare and monitor a programme for each product development project.

You will have a relevant science degree and 3-5 years' regulatory experience. Good written and oral communication skills are essential, as is the ability to work under pressure.

We offer a competitive salary supported by a substantial range of fringe benefits normally associated with a major international company including relocation assistance where appropriate.

This opportunity is open to both men and women.

Please write, quoting ref: CP110, with full career and salary details, to: J. Flint, Personnel Manager, FBC Limited, Chesterford Park Research Station, Saffron Walden, Essex CB10 1XL.

FBC Limited is a subsidiary of Schering AG, West Germany.



### BRUNEL UNIVERSITY Department of Chemistry LABORATORY SUPERINTENDENT

(Re-advertisement)  
Applications are invited for the post of Departmental Laboratory Superintendent in modern laboratories located on the Uxbridge campus. The post carries responsibility, under the direction of the Head of Department, Professor G. C. Bond, for the organisation of the work of technician staff, the operation of the research and teaching laboratories, and the implementation of budgetary control on expenditure for chemicals and equipment.

Applicants should be qualified to at least HNC or HTEC or equivalent standard, and should have relevant experience as a laboratory technician at a senior level. Candidates should have a good knowledge of modern instrumental techniques and be fully conversant with safety requirements. Previous candidates need not re-apply.

The salary will be an appropriate point on the grade 8C scale £10 320-£11 177 (including London Weighting) according to age, qualifications and experience.

Application forms and further details are available from the Personnel Secretary, Brunel University, Uxbridge, Middlesex, UB8 3PH, on receipt of a self-addressed envelope. Closing date: 30 April, 1985.

Brunel University is an Equal Opportunity Employer.

### IMPERIAL COLLEGE Department of Biochemistry POSTDOCTORAL RESEARCH ASSISTANT

required for an MRC funded post to assist a programme of research into the characterisation of glycoproteins and complex carbohydrates, using advanced mass spectrometric techniques. The successful applicant will join a multidisciplinary team under the direction of Professor H. R. Morris and Dr A. Dell.

The investigations will involve principally the study of cell surface antigens and will make use of HPLC purification and fast atom bombardment mass spectrometry. Previous experience in mass spectrometry is not essential but applicants must be motivated towards using sophisticated instrumentation as part of their research activities. Experience in HPL of biopolymers is desirable.

The Appointment will be on the RA 1A scale £7520-£12 150 + £1233 London Allowance.

Applications with full cv and names and addresses of two referees to Dr A. Dell, Dept. of Biochemistry, Imperial College, London SW7 2AZ.

### ST BARTHOLOMEW'S HOSPITAL, West Smithfield, London EC1A 7BE

#### Anaesthetic Laboratory MEDICAL PHYSICS TECHNICIAN IV/III

Salary: £6488-£9367 (Grade IV/III). Depending on qualifications and experience.

The Anaesthetics Laboratory provides patient monitoring services and technical support to the Intensive Care Unit and Operating Theatres.

To arrange an informal visit please contact Mrs A. Wright on Tel 01-600 9000, Ext 2458.

Application forms can be obtained from the Personnel Department on Ext 3188 quoting ref no MM/41.

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Ph.D. Medical Physics or Chemistry with NMR and Diagnostic Imaging experience. Must be diplomatic yet decisive while in control of an environment of highly intelligent and demanding personalities. Relocation to United States; travel within U.S. and to Europe. Will develop biomedical instrumentation, perform research for future projects, write papers in collaboration with university personnel and present papers to professional groups.

Salary commensurate with education and experience.

Send complete resume including salary history to:

K.B. Wolfe

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## BIOCHEMIST

We require a young Biochemist, with PhD or equivalent research experience, for our Biochemical Development Department.

The role of this department is to provide technical support for our range of biochemical reagents, and new products. The successful applicant will be expected to play a major part selecting and developing the latter.

A wide knowledge of biochemistry and interest in all aspects of the subject is a pre-requisite. Laboratory work is most likely to be concerned with the application of separation and analytical techniques, and will involve the preparation of protein, nucleic acids etc as reference materials. Particular emphasis will be placed upon chromatography and product development for electrophoresis. The Biochemist may also be required to supervise a small group and to maintain extensive contacts outside the Company with Universities etc.

We are situated in an attractive part of the country, and can offer a competitive salary with contributory pension scheme, annual bonus and other benefits expected from a large Company.

Please apply in writing, giving full details of age, experience, qualifications and current salary to: Mr J. M. Gordon, Personnel Officer, BDH Chemicals Limited, Bromford, Poole BH12 4NN. Quoting *New Scientist*.



## THE UNIVERSITY OF LEEDS

### DEPARTMENT OF BIOCHEMISTRY

### POSTDOCTORAL RESEARCH FELLOW

Applications are invited for the above post for the study of haem metabolism in plants and its significance in the synthesis and organisation of photosynthetic pigments. The successful applicant will join a group studying various aspects of tetrapyrrole biochemistry and their application to medical and biological problems.

The post is funded by the SERC and is available for a fixed period of up to three years from a starting date to be agreed, but not later than 1 October, 1985. Applicants should hold, or expect to hold shortly, a PhD in a relevant discipline.

Informal enquiries may be made to Dr S. B. Brown (Tel 0532 431751, Ext 7500).

Salary on the 1/A Range for Research and Analogous Staff (£7520-£12150) (under review) according to age, qualifications and experience.

Application forms and further particulars may be obtained from the Registrar, The University, Leeds LS2 9JT quoting Ref 83/60. Closing date for applications 2 May, 1985.

## Molecular Biochemist

Midlands

Our client is a subsidiary of a large UK company with an expanding interest in the genetic modifications of yeast.

This new position is being created to support the activities of a team of Molecular Biologists.

The salary is highly competitive and will be commensurate with age and experience.

Candidates, male/female, must possess a degree (or equivalent) in Biochemistry or a related discipline and preferably have experience in fermentation techniques and the purification and characterisation of proteins.

**Confidential Reply Service:** Please write with full CV quoting reference M495 on your envelope, listing separately any company to whom you do not wish your details to be sent. CV's will be forwarded directly to our client who will conduct the interviews.

Charles Barker Human Resources (Midlands) Limited, 19th Floor, Kennedy Tower, Snow Hill Queensway, Birmingham B4 6JB.

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# Pharmaceutical Analytical Technician

## Egham

Merrell Dow Pharmaceuticals Limited is a major research based pharmaceutical company with a wide range of exciting new medicines under development.

The Merrell Dow Research Institute at Egham now wishes to appoint a further well-qualified Technician in the Analytical Chemistry Department.

The person appointed will be educated to at least HNC/Higher TEC standard with ideally several years' experience in an analytical chemistry laboratory. Recently qualified graduates will also be considered.

Reporting to a senior scientist, the work involves the development of methods for the analysis of a range of new drugs and is interesting and varied.

Experience in modern analytical

techniques including HPLC and GLC with computerised data handling is desirable, together with a co-operative attitude towards work with a young enthusiastic project-orientated team.

Our remuneration package will include a competitive salary related to qualifications and experience, pension scheme and life assurance, together with other benefits such as flexible working hours, pleasant site location and facilities and private health insurance.

Please apply giving details of your background and experience to Mrs D. M. Helmer, Personnel Manager, Merrell Dow Pharmaceuticals Limited, Meadowbank, Bath Road, Hounslow, Middlesex TW5 9QY.

# Merrell

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## Physicist

### for a key role in production

Triplex Aircraft and Special Products Division, based in Birmingham, is a member of the Pilkington Group and a world leader in high technology transparencies for the aerospace and associated industries.

We are seeking a Graduate in Physics or a related discipline for the post of Senior Shift Technologist in our Production Department. This is a staff position which involves the technical supervision of thin films coatings plant. The successful applicant will co-ordinate the activities of technologists working on other shifts.

This is an excellent opportunity for a young man or woman to gain valuable experience before moving to a more responsible position. Production experience, and knowledge of vacuum coatings technology, would be a distinct advantage.

We offer an attractive salary together with a wide range of large group benefits including relocation assistance, if appropriate.

Please write with full career history and details of current salary to Peter Molineux, Personnel Manager,

**Triplex** 

Triplex Safety Glass Co Ltd.,  
Eckersall Road, Kings Norton,  
Birmingham B38 8SR.

## KING'S COLLEGE LONDON Department of Pharmacology TECHNICIAN GRADE 3

Applications are invited for a post funded by the British Heart Foundation for two years to work on effects of a pulsatile blood pressure on brain function. The work, under Professor Bradbury, will involve radiochemical and biochemical analyses of brain tissue together with maintenance and handling of physiological equipment, e.g. micro-blood gas analyzers. Some background in one or more of these fields is desirable, in addition to minimum ONC or equivalent plus 3-5 years relevant experience.

Salary £5399 pa plus £1260 London Allowance (under review). Five weeks annual holiday, plus six extra days when the College is closed. Season ticket loan. Contributory Superannuation Scheme.

Applications to Mr. G. A. Cuthbert, Assistant Secretary (Personnel) King's College London, Strand, WC2R 2LS, or Tel Professor Bradbury for further information on 01-838 5454, Ext 2547.

Closing date for applications 26 April, 1985.

## UNIVERSITY OF EDINBURGH Department of Genetics

Applications are invited for the position of

### POSTDOCTORAL RESEARCH FELLOW

to work on a project aimed at investigating the role of cellular oncogenes and growth factor genes in the selection of mice and chickens for growth and growth rate. The project would involve a number of nucleic acid, protein electrophoretic and immunochemical techniques and experience in one or more of these would be an advantage. The project will involve active collaboration with groups within the Department and the Collaboration Research Centre (Roslin, Midlothian), already working on the various aspects of the selection response for growth.

The post is grant funded by the Agricultural and Food Research Council for a period of three years and is available immediately.

Salary on range 1A scale with minimum start point of £15,200, placing being determined by age and qualifications.

The project is under the direction of Dr Andrew Tett who will provide further details as required.

Applications together with full CV and the names and addresses of two referees should be sent, by 31 May, 1985, to: The Secretary's Office, Old College, South Bridge, Edinburgh.

Please quote reference No 5245.

## UNIVERSITY OF LIVERPOOL Department of Genetics Molecular Genetics

Applications are invited for the post Research Assistant/Senior Research Assistant for a three-year project working on the mechanisms of DNA repair and mutagenesis encoded by bacterial plasmids. The project involves extensive use of recombinant DNA techniques and DNA sequencing, and experience in these areas would be an advantage. A graduate appointee would have the opportunity to register for a higher degree. The post is available immediately, but could be held open for a suitable candidate expecting to graduate in June, 1985. Informal enquiries may be made to Dr Strike (Tel 051-709 6022, Ext 3113).

Initial salary within the range £6600-£8450 pa.

Applications, together with the names of three referees, should be received not later than 25 April, 1985, by the Registrar, The University, PO Box 147, Liverpool L69 3BX, from whom further particulars may be obtained.

Quote Ref: RV/228/NS.

## Chemist Organic Synthesis

Merck Sharp & Dohme Research Laboratories is a leading international pharmaceutical research organisation which has newly established a Neuroscience Research Centre in a 30 acre park near Harlow, Essex. The Centre will be one of the world's largest laboratories dedicated to neuroscience research, initially focusing on the study of inhibitory chemical messengers in the brain and exploration of the functional role of neuropeptides in the control of emotion, appetite, memory and learning.

As part of the Centre's planned growth we are seeking to recruit a Graduate Chemist who has specialised in Organic Synthesis and gained a minimum of two years experience in Medicinal Chemistry within pharmaceutical research.

We are offering a substantial remuneration package, although of equal importance will be the opportunity to work in a stimulating and rigorous scientific environment.

If you feel that you meet our requirements then write enclosing a full Curriculum Vitae to:

**Mr. Andrew Harley, Personnel Manager, Merck Sharp & Dohme Research Laboratories, Neuroscience Research Centre, Terlings Park, Eastwick Road, Harlow, Essex CM20 2QR.**



MERCK  
SHARP  
DOHME



Neuroscience Research Centre

## REACTOR PHYSICS ASSISTANT

NORTH WALES

£10 575-£14 031 pa

The Central Electricity Generating Board invites applications for the post of Reactor Physics Assistant to work within the Reactor Physics Group of the Performance Section at:

WYFLA POWER STATION on the Isle of Anglesey in North West Wales.

The vacancy will be filled by a person who will be involved in calculational and other work concerned with the safe operation of the reactors, reactor refueling strategies and optimising reactor life. The applicant will also be involved in liaising with reactor operations staff and will from time to time be called on to work out of normal office hours.

The successful applicant is expected to have a basic knowledge of physics either at degree level or its equivalent. Knowledge of reactor physics would be an advantage—however suitable applicants will receive training in the subject.

Applications in writing, from either sex giving details of age, experience etc to The Personnel Manager, Central Electricity Generating Board, Europa House, Bird Hall Lane, Cheshire Heath, Stockport, Cheshire SK3 0XA, to arrive no later than 30 April 1985.



## Synchrotron Radiation Research Technical and Scientific Support

The Daresbury Laboratory, situated in North Cheshire, operates major national facilities for fundamental and applied research in a wide range of sciences.

Vacancies exist for scientists and engineers to join the teams which are responsible for the experimental research equipment at the Synchrotron Radiation Source. The equipment already installed covers a wide range of techniques associated with physics, chemistry and biological sciences and includes x-ray spectrometers, high resolution grating and solid-state detectors. Staff appointed will be expected to accept responsibility for the installation, operation, maintenance and development of systems such as optical instruments for the infra-red, ultra violet or x-ray regions, sample chambers, cryogenic equipment, detectors and data collection hardware and software. Applicants, of either sex, are sought with experience in ultra-high vacuum systems, optics, scientific instruments and electronics (involving both digital and analogue circuitry).

As well as having an HNC/HND or a degree (or equivalent) qualification in a physical science subject and/or engineering, applicants are expected to have a strong practical approach to scientific instrumentation and to be able to respond with energy, enthusiasm and adaptability whilst working as a member of a team within an expanding multi-disciplinary environment. Previous relevant experience in a research context would be an advantage for some of these posts and applicants with this type of experience would be encouraged to develop their research interests in the synchrotron radiation field.

Appointments to these posts will be made within the grades of Scientific Officer, Higher Scientific Officer, Professional and Technology Officer 3 or 1 according to qualifications and experience on a salary range from £5,908 to £10,038 per annum for SO/HSD and £7,465 to £10,165 per annum for PTO 3/2.

Appointments allow for a non-contributory superannuation scheme and generous leave allowance. There is also a flexible working hours scheme in operation.

CLOSING DATE 2nd May, 1985.

Further information may be obtained on Ext. 487

Warrington (0695) 88000.

Application forms may be obtained from and should be returned, quoting reference DL/908, to:

The Personnel Officer,  
Daresbury Laboratory, Science and  
Engineering Research Council,  
Daresbury, Warrington,  
Cheshire WA4 4AD.

**Daresbury**  
SCIENCE & ENGINEERING  
RESEARCH COUNCIL

## Research Scientist

A vacancy exists in the Biodegradability Section of WRC Environment at the Medmenham Laboratory for a scientist to work in a team investigating how micro-organisms in the aquatic environment degrade xenobiotic chemicals.

The successful candidate will have a good honours degree in Biochemistry or an allied subject and have an interest in environmental science. Candidates must be able to demonstrate wide research experience in the assessment of aerobic and anaerobic biodegradability in toxicity to bacteria, or in similar microbial investigations. A knowledge of national and international legislation governing the marketing of new chemicals, of hazard assessment and experience of some form of good laboratory practice would be an advantage.

Salary will be in the range £9,486 p.a. to £11,742 p.a. depending on age and experience. Excellent conditions of employment include a contributory pension scheme and flexible working hours. 22½ days holiday.

Written requests only for an application form quoting Post 169 to Pamela Stafford, Personnel Department, Water Research Centre, Medmenham Laboratory, Henley Road, Medmenham, PO Box 16, Marlow, Bucks SL7 2HD.

Closing date: 26 April 1985.

WATER RESEARCH

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Environment

Providing Water Technology Worldwide



# ENVIRONMENTAL RESEARCH IN THE CEGB

The CEGB is conducting a substantial research programme on the possible effects of atmospheric pollution on terrestrial and aquatic ecosystems. This includes work on the catchment processes determining surface water quality and on soil mediated effects of pollutants on the growth of crops and trees. Soil interactions are central to both.

Research opportunities exist at the Central Electricity Research Laboratories Leatherhead which is one of the CEGB's principal laboratories, for recently qualified scientists with appropriate research experience in soil microbiology, geochemistry, hydrology or in related areas.

Starting salaries for newly qualified applicants with a PhD are approximately £9,400 but will be higher for those with post doctoral experience. Excellent prospects exist of advancement to salaries in the order of £17,000 and beyond.

Those who have the required qualifications and appropriate background and wish to be considered for these vacancies should send immediately, details of age, qualifications, experience etc. to Mr A Allen, Head of Personnel Section, Central Electricity Research Laboratories, Kelvin Avenue, Leatherhead, Surrey KT22 7SE quoting reference NS/185.

The CEGB is an Equal Opportunities Employer.

**CENTRAL ELECTRICITY GENERATING BOARD  
TECHNOLOGY PLANNING AND RESEARCH DIVISION**



## Mass Spectrometry A Specialist Role

**Salary c. £12,000**

**Dartford, Kent**

An excellent opportunity has arisen, within one of our well equipped laboratories, for a Mass Spectroscopist.

Based within the Physical Methods Section of our analytical laboratories you will be responsible for providing a specialist service to a range of departments on our Dartford site. This would include the development of GC-MS and HPLC-MS techniques for the analysis of materials of interest to the Company.

Probably aged around 30, you should be educated to degree level and have several years relevant post-graduate experience.

Excellent benefits will include:-

- 5 weeks holiday
- Generous sick pay scheme
- Subsidised staff restaurant
- The best sports and social facilities in the area
- Relocation assistance.

The Wellcome Foundation is an international group of pharmaceutical and chemical companies with headquarters in the United Kingdom and with an annual turnover in excess of £800m.

For further details and an application form, please write to or telephone Alan Murdoch, Senior Personnel Officer, The Wellcome Foundation Limited, Temple Hill, Dartford, Kent. Telephone: Dartford (0322) 23488, ext. 2263.



**Wellcome**

### AFRC FOOD RESEARCH INSTITUTE-BRISTOL SENIOR SCIENTIFIC OFFICER

A vacancy has arisen for a Protein Biochemist to lead a group working on the biochemistry of collagen and connective tissues. The main topics at present are the chemistry of the collagen cross-links in mature animals, the packing of collagen molecules in fibrils, the characterisation of ep-, peri- and endomysium collagen using immunochemical procedures and the development and control of muscle collagen using recombinant DNA models. The appointed scientist will be expected to initiate and develop these and new fundamental programmes, to relate them to structural work on collagen fibrils and to applied work on meat texture.

**Qualifications:** At least four years' experience in protein biochemistry essential (preferably in collagen research) with preferably a PhD in biochemistry, biophysics, cell biology or related subject.

**Salary:** £9329-£12 050

Application forms from: The Personnel Officer, Food Research Institute-Bristol, Langford, Bristol BS18 7DY.

Quoting ref: 84/28.

### ROYAL POSTGRADUATE MEDICAL SCHOOL (University of London)

#### Paediatrics and Neonatal Medicine

#### A POSTDOCTORAL SCIENTIST

is required in the Jerry Lewis Muscle Research Centre to work on a project supported by Action Research. The project, to be carried out in collaboration with Dr K. Davies (Oxford), is concerned with identification and characterisation of gene products associated with Duchenne muscular dystrophy.

Techniques used will include mRNA preparation, hybrid selection, *in vitro* translation and two-dimensional gel electrophoresis. Experience in molecular biology and/or protein techniques an advantage.

Starting salary on appropriate point of Range 1A scale for Research and Analogous Staff according to age and experience.

Applications by letter enclosing cv and the names and addresses of two referees should be sent to the Personnel Office, Royal Postgraduate Medical School, 150 Duane Rd, London W12 0HS quoting ref: 28/270.

Closing date: 25 April, 1985.

### CHARING CROSS AND WESTMINSTER MEDICAL SCHOOL

(University of London)

#### RESEARCH TECHNICIAN

required for three years for project investigating factors relating to arterial bypass patency. Appointee will be responsible for ultra-centrifugal, chemical and electrophoretic analysis. Experience preferred, but training is offered. Registration for a research degree is not precluded.

Salary within £5738-£6924 pa plus £1042 pa London Weighting Allowance.

Further information from Mr Norman Woolcock, Department of Surgery, Tel 01-748 2040, Ext 2196 and applications on forms obtainable from The Secretary, Charing Cross and Westminster Medical School, The Reynolds Building, St. Dunstan's Road, London W8 8RP, to be submitted within four weeks of the appearance of this advertisement.



**Anglian Water**

**AREA OPERATIONS  
ENGINEER**

**Salary: £10 500 to £11 742**

We require an Area Operations Engineer for the Water Supply Department at our offices in Cambridge Road, Bedford.

The successful applicant will be required to examine, develop and recommend measures to improve operational efficiency and to co-ordinate and monitor leakage control. This will also involve participation in the formulation of corporate aims, assistance with energy audits, etc.

Applicants should preferably be educated to degree level and be able to demonstrate a high level of numeracy. Previous experience in the water supply industry advantageous, computer experience essential.

A job description and application form are available from the Personnel Department, Telephone Cambridge 61561 Ext 240 (quoting Post Reference WQ101).

Closing date for receipt of applications 26 April, 1985.

**CAMBRIDGE DIVISION**

Great Ouse House, Clarendon Road,  
Cambridge CB2 2BL

**THE CAMPDEN FOOD  
PRESERVATION RESEARCH  
ASSOCIATION**

Chipping Campden, Glos GL55 6LD  
RESEARCH OFFICER

Applications are invited from Honours Graduates in a food-related subject to work in the Department of Quality in the field of sensory evaluation of foods. The successful applicant will occupy a senior position within the Department and be responsible for the development of suitable methods for measuring quality in fresh horticultural produce and the preparation of standards and specifications for processed foods. Other duties will include the co-ordination and supervision of sensory panel training and liaison with member companies on all aspects of sensory testing. Previous experience of sensory evaluation would be a distinct advantage but is not essential as on-site training will be given. This is an exciting opportunity for the right person to join a team of enthusiastic technologists involved in a rapidly growing and important discipline at the RA.

Application forms are available from the Secretary-General.

**THE UNIVERSITY OF SHEFFIELD  
DEPARTMENT OF  
MICROBIOLOGY  
NEW BLOOD  
LECTURER IN  
MICROBIAL  
PHYSIOLOGY**

The new lecturer will be a member of the staff of the Department of Microbiology (Head of Department, Professor D. W. Tempest). Applications would be particularly welcomed from those with a special interest in the physiological behaviour of micro-organisms in extreme environments. Candidates should normally be under 35 but older candidates will be considered. Initial salary on the scale for Non-Cl. Lecturers £7520-£14 925 a year. Particulars from the Personnel Department (Academic Staffing), The University, Sheffield S10 2TN to whom applications (6 copies) including the names of three referees should be sent by 24 April 1985 (This closing date has been extended). Please quote ref: R239/H.

**SOUTH EAST THAMES REGIONAL HEALTH AUTHORITY**

Statistics and Operational Research Department

**STATISTICIANS**

GAA. Salary: £5925 - £7737  
HCO. Salary: £4897 - £5925

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We are looking for highly motivated and articulate graduates with degrees in numerate disciplines. New graduates are eligible, but for the GAA at least a year's relevant experience will be required.

The posts are based in modern offices in our new Headquarters at Bexhill-on-Sea. Flexible working hours are in operation, and there is a staff restaurant and leisure facilities.

For further details and an application form please contact the Personnel Department, SETRHA, Thrift House, Collington Avenue, Bexhill-on-Sea, East Sussex TN39 3NQ, telephone (0424) 222555 Ext. 3145, or for an informal chat about the posts, telephone Deana Leadbetter, the Regional Statistician on Ext. 3355. Ref: 521/NS.

Closing date: 26 April, 1985.

**BRISTOL POLYTECHNIC**

Science Department

**Principal Lecturer in Analytical  
Science**

Ref No. L/13

Applications are invited for this new post within the Department. The successful candidate will be expected to take responsibility for the co-ordination and development of teaching within the field of analytical science and instrumentation across the biological and physical science courses in the department. High academic qualifications and substantial research and/or industrial experience are sought rather than any one particular speciality. An ability to initiate and pursue research and/or consultancy in some aspect of instrumental analysis is essential.

Salary scale: £13 095-£14 580 (bar)-£16 467 per annum.

For further details and an application form, to be returned by 22 April, 1985, please contact the Personnel Office, Bristol Polytechnic, Coldharbour Lane, Frenchay, Bristol or ring Bristol 656261, Ext 216 or 217.

Please quote Reference Number L/13 in all communications

**SUNDERLAND POLYTECHNIC**  
Faculty of Pharmaceutical Sciences  
Department of Pharmacology

**LII IN PHARMACOLOGY  
1 YEAR FIXED TERM**

REF A12

**SALARY: LII £7548-£11 175 BAR £12 099 (under review)**

Responsible for teaching pharmacology and/or physiology, biochemistry and toxicology to students reading for degrees in BSc (Hons) Pharmacology; BSc (Hons) Pharmacy; or BSc Combined Studies in Science. Research activities will be encouraged.

An application form and further particulars may be obtained from Personnel Officer, Sunderland Polytechnic, Langham Tower, Ryhope Road, Sunderland SR2 7EE or telephone (0783) 76231 Ext 11.

Closing date: 26 April, 1985.

**GREATER GLASGOW HEALTH  
BOARD**

Unit North 1, Stobhill General  
Hospital

Dept. of Bacteriology  
ML50

Applications are invited for the above post, tenable for one year in the first instance, in the Phase Typing section of the Scottish Salmonella Reference Laboratory. The laboratory is situated within the Bacteriology department at Stobhill General Hospital, and provides a Salmonella typhimurium phase typing service for Scotland.

Applicants should be state registered, and should hold Associateship of the IMLS or an equivalent qualification. Candidates should preferably have experience of the identification of Enterobacteriaceae, although this is not essential, as full training will be given.

Further details and application forms are available on request from Mr D. Munro, Scottish Salmonella Reference Laboratory. Applications should be sent to Dr R. W. A. Girdwood, Director, Scottish Salmonella Reference Laboratory, Stobhill General Hospital, Glasgow G21 3UW.

**UNIVERSITY OF LEEDS**

**Research  
Technician**

Rheumatism Research Unit

Required for Clinical Pharmacology Unit, Royal Bath Hospital, Cornwall Road, Harrogate, North Yorkshire. The work will involve drug assays and biochemical assays in biological fluids. Previous experience with HPLC will be an advantage. Applicants must be qualified to ONC or equivalent level and have 3-5 years relevant experience (including training period). This appointment will be for two years.

Salary will be Grade 3 £5399 £5325 pa.

Applications giving details of age, education and experience should be sent to Dr J. S. Dixon at the Harrogate address by 25 April, 1985.

# Amersham

## Use Your Science in Manufacturing...

Amersham International's Medical Product Division is a rapidly growing business producing specialised products for the clinical diagnosis of a wide variety of disease states. We aim to maintain our competitive edge by the introduction of a steady stream of relevant new products including a complete new non-radioactive immunodiagnosics system. The application of science plays a key part in the development and manufacture of our products.

As a life science graduate with up to two years work experience, preferably in a fast moving science based industry, you will by now know your own capabilities. You might like to spend a moment matching them to our requirements.

We are looking for enthusiastic professionals who are analytical and numerate but who at the same time have good communication skills and a persuasive approach. As a Project Co-ordinator within Medical Products Division, Cardiff you will need all of these attributes to perform tasks which range from the evaluation of production methods, experimental design and the development of test procedures to the co-ordination of a complex product from development through its manufacturing stages. This position offers an excellent opportunity for a future career with Amersham International - based on past experience it could lead to posts in Manufacturing, Marketing or R & D.

The starting salary will be based on qualifications and experience, within the scale ranging from £7,855-£11,785. Conditions of service are excellent and include good holidays and a contributory pension scheme.

**Demonstrate your interest and ability by immediately telephoning Mr. R.H. Hart-Jones, Recruitment Officer, in the first instance, on Cardiff (0222) 617221. Cardiff Laboratories, Amersham International plc, Forest Farm, Whitchurch, Cardiff CF4 7YT.**

### UNIVERSITY OF LIVERPOOL

**Department of Physics  
PROGRAMMER/PHYSICIST  
EXPERIMENTAL OFFICER/  
SENIOR EXPERIMENTAL  
OFFICER**

Required to join the Research Group in Nuclear Structure Physics. The successful candidate will be required to continue the development of suites of interactive graphics programmes for the GEC4 190 computers at the Department of Physics, Liverpool and the Daresbury Laboratory, Warrington. Programming of the new GEC 6330 computer for data analysis at Daresbury and of the IBM PCs at Liverpool will also be required. A suitable candidate would also collaborate in experiments carried out with the NSF heavy ion accelerator.

The minimum qualification for Experimental Officer level is an Honours Degree in a relevant subject and additionally Senior Experimental Officers must have at least five years' appropriate experience.

The Experimental Officer salary range is £6800-£8920 pa, and the Senior Experimental Officer salary range is £7500-£12 150 pa, depending on qualifications.

The post is tenable for two years. Application forms and further information may be obtained from The Registrar, The University, PO Box 147, Liverpool L69 3BX. Quote Ref: RV/215/NS.

### WEST LAMBETH HEALTH AUTHORITY

St Thomas' Hospital, London SE1 7EH

## RESEARCH ASSISTANT (BIOCHEMIST) IN HAEMATOLOGY

Research Assistant (Biochemist) required to work on DNA sequence analysis involving gene re-arrangements and gene transcription in cells from blood neoplastic disorders. Experience in gene mapping and cell tissue culture techniques an advantage.

Salary on scale £7500 to £8500 plus £1084 London Weighting Allowance per annum, according to age, qualifications and experience. Appointment is for one year in the first instance.

For further details and an application form contact the Personnel Department, St Thomas' Hospital. Tel 01-928 9292, Ext 2422. Closing date: 25 April, 1985.

### UNIVERSITY OF EDINBURGH

**DEPARTMENT OF GENETICS  
A Postdoctoral Scientist**

is required to work on the development and application of DNA probes for embryonic sex assignment in farm animals. The work is supported by an AFRC project grant for three years. Training and experience in gene cloning and associated techniques essential. Salary on range 1A scale commencing at £8920 rising to £10 530 in the third year. The project is under the direction of Dr K. W. Jones who will provide further information as required.

Applications with full CV and names and addresses of two referees should be sent by 31 May, 1985 quoting Ref No 5244 to:

The Secretary's Office,  
Old College,  
South Bridge,  
Edinburgh.

# UWIST

### UNIVERSITY OF WALES

Welsh School of Pharmacy

**'NEW BLOOD' Lecturer**

**Physical Pharmaceutics**

Salary: £7520-£14 925 per annum

Requests (quoting Ref C42) for details and application form to Staffing Office, UWIST, PO Box 68, Cardiff CF1 3XA.

Closing Date: 17 May, 1985.

### ST MARY'S HOSPITAL MEDICAL SCHOOL and

Paddington & North Kensington Health Authority

**LECTURER IN HEALTH EDUCATION**

This is a new post, funded by the Health Education Council, initially for three years. It is expected that the holder's interests will centre on the problems of inner city deprivation and the potential of community-based initiatives in health education. Candidates should have had experience in health education or teaching, and in research, preferably related to health education. A higher degree or other further qualifications would be an advantage. The salary is on the University Lecturer scale £7520 to £14 925, plus £1233 pa London Allowance.

Informal enquiries may be directed to Professor David Miller (01) 927-1673, Dr William Keen (01) 927-1505 and Mr John Dodds (01) 286-3275.

Details from Assistant Secretary (Personnel): St Mary's Hospital Medical School, Norfolk Place, London W2 1PG to whom application in the form of a full CV and names and addresses of two referees should be sent by 3 May, 1985.

## LABORATORY DIAGNOSTICS

**Sales Specialists  
up to £9500 + car**

**NE MIDLANDS NW**

A chance to join an innovative and well-respected diagnostics company, specialising in Biochemistry, Immunology and Microbiology.

Ambitious, determined candidates with HNC/BSc in a relevant discipline and at least two years laboratory experience are invited to apply. Preferred age 23-30. Clean driving licence essential.

01-222 1547

**Ross Warren  
Recruitment**

### CHELSEA COLLEGE

University of London

**Department of Pharmacy**

Applications are invited for the post of

**TECHNICIAN GRADE 3**

in Pharmaceutics Section.

Duties will include the servicing of undergraduate classes, occasional assistance with research, the care and maintenance of equipment.

Applicants should possess TEC or equivalent qualification and have appropriate experience, preferably of chemical or biochemical laboratory work.

Salary scale: £3590-£6325 pa plus £1250 London Allowance.

The appointment will be for two years in the first instance.

Application forms and job description from: Mr D. C. Grant, Department of Pharmacy, Chelsea College, University of London, Manresa Road, London, SW3 6LX. The closing date is 25 April, 1985.

**WANDSWORTH HEALTH  
AUTHORITY****Sub-Regional Department of  
Medical Physics****St James' Hospital, Balham SW12  
SENIOR GRADE PHYSICAL  
SCIENTIST/BIOENGINEER/  
ELECTRONICS ENGINEER**

A vacancy exists for a Physical Scientist/Bioengineer/Electronics Engineer to provide physics and bioengineering services to St James' Hospital, Balham, mainly in the areas of physiological measurement and patient instrumentation. Duties will range from responsibility for the assessment, calibration and maintenance of patient orientated equipment, to the design of projects and the development of clinical instrumentation not available commercially.

This is a new post in a new Section of the expanding and lively Sub-Regional Department of Medical Physics, based at the adjacent St George's Hospital, Tooting. The post will be supported by the appointment of an electronics and maintenance technician at St James' Hospital and by the laboratories and workshops of the main Department.

The person appointed must have a good and appropriate honours degree and a minimum of four years experience in the field of clinical instrumentation and electronics. Salary: £9415-£12 173 pa, plus £1084 pa London Weighting.

For further information please contact Dr B. J. Perry, Chief Physicist, St George's Hospital, SW17. Tel 01-672 1255, Ext 5089.

For job description and application forms please contact: Personnel Department, St James' Hospital, Sandford Road, Balham SW12. Tel 01-672 1222, Ext 164.

Closing date 1 May, 1985.

**BRUNEL UNIVERSITY****Faculty of Mathematics & Science  
INDUSTRIAL TRAINING  
OFFICER**

Applications are invited from graduates for the post of Industrial Training Officer to organise the placement of undergraduates in Applied Sciences undertaking training in industry, commerce or government organisations as part of their degree courses.

Experience in industry or commerce would be helpful, and some previous history of employment outside the education sector is essential, together with proven administrative ability.

The position is available from 1 June, 1985, or as soon as possible thereafter. The salary will be on the national administrative scale 1A £6600-£12 150 (under review) plus £1233 London Allowance, with USS benefits with the opportunity for promotion to scale II.

Further information and application form may be obtained from the Personnel Secretary, Brunel University, Uxbridge, Middlesex UB8 3PH. Closing date: 3 May, 1985.

Brunel University is an Equal Opportunity Employer.

**FISHERY/RETAIL ASSISTANT**

Currently required at Horton Trout Fishery. Full time position includes some weekend work, overtime available and some compulsory overtime in the winter. Position would suit an honest reliable individual with an interest in angling.

Apply to: The Fishery Supervisor, Kingmead Fish Farms Ltd, Stanwell Road, Horton, Slough, Berks SL3 9PE. Tel Slough 684858.

# R & D Scientists/Engineers

**SW LONDON****up to £13,005**

Watson House has a worldwide reputation for its research into the use of gas in the domestic and small commercial markets, and for the testing and approval of gas appliances in these major areas.

## Scientist/Engineer – Domestic and Commercial Heating

To join a group studying the use of gas for domestic and commercial heating. The main area of involvement is energy conservation. Investigative projects range from studies involving high-efficiency – condensing appliances to detailed examination of the meteorological, sociological and economic factors which combine to influence the use of gas.

Data analysis is a major part of the work, and familiarity with computer based systems is essential. Candidates will be graduates in engineering, physics or other relevant discipline, with at least three years' experience in a related field. A current driving licence is desirable. Ref: WH/407/NS.

## Analyst/Engineer – Reliability Data

To join a team responsible for assessing and improving the reliability of domestic gas appliances. The work spectrum covers all areas of the team's activities, with particular emphasis on the operation of a large-scale database and the development of computer techniques for collection and statistical analysis of data.

Candidates will ideally be programmers/statisticians with an interest in engineering. Alternatively, they could be essentially engineers with a strong computing background. Previous experience would be an advantage. Ref: WH/408/NS.

Both posts carry salaries within the range of £7,791 to £13,005 (including Inner London Weighting) depending on qualifications and experience. Benefits are those normally associated with a large, progressive organisation.

Please write for an application form, quoting the appropriate reference number, to: Personnel Officer (Fulham), British Gas, Watson House Research Station, Peterborough Road, London SW6 3HN – or telephone Mrs White on 01-736 1212 ext. 3358.

**BRITISH GAS**

## MEDICAL RESEARCH COUNCIL BIOCHEMICAL PARASITOLOGY UNIT MOLTENO INSTITUTE UNIVERSITY OF CAMBRIDGE

## POSTDOCTORAL ASSISTANT

Applications are invited for the post of post-doctoral assistant to work with Dr R. A. Klein and Dr B. Schmitz, in collaboration with Professor Dr Egge of the University of Bonn, on the structure of the carbohydrate moiety of the surface antigen from *Trypanosoma brucei*.

Knowledge of protein and/or carbohydrate chemistry is desirable; the work will involve the preparation, purification and analysis of glycoprotein fractions.

The appointment, which will run from 1 July, 1985 to 31 December, 1986, is funded by the Commission of the European Communities. The salary will be in the range £7520-£8450, subject to the usual MRC conditions of employment.

Applications, together with the names of two referees who should be asked to write directly by the applicant, should be sent to Dr R. A. Klein, Medical Research Council, Molteno Institute, University of Cambridge, Downing Street, Cambridge CB2 3EE (Tel 0223-350577) to arrive not later than 1 May, 1985.

## UNIVERSITY OF OXFORD

**Sir William Dunn School  
of Pathology**

## RESEARCH ASSISTANT Grade 1B

**Salary scale £6600-£10 330**

A Research Assistant is required from 1 June, 1985 to contribute to a programme of cancer research under the direction of Professor Henry Harris FRSc. The work involves extensive use of cell culture and somatic cell genetics. Experience of these techniques would be a major advantage. The successful applicant must have a degree and should have a good biological or biochemical background. Applications, with the names of two referees, to the Administrator, Sir William Dunn School of Pathology, South Parks Road, Oxford OX1 3RE.

# FBC

*FBC Limited is an international company in the field of agrochemicals and livestock products, with a strong research base and certain industrial chemical interests. It has a leading position in the British market, associated companies in a number of overseas countries and an annual turnover in excess of £100 million.*

## These posts are based near Cambridge Formulation Chemist

You will be involved in the design and development of formulation systems for new and existing compounds intended for crop protection or veterinary use.

You will be a graduate in chemistry or related science and preferably have some practical experience of formulation work. Ref. 9881.

## Senior Formulations Assistant

Expansion of the Formulations Department has created a vacancy for a Senior Formulations Assistant.

Under the supervision of an experienced Formulations Chemist, you will be involved in the design of formulations systems for new and existing products.

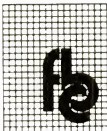
You will be a young chemist with HNC or a pass degree, preferably with some practical experience of formulations work. Ref. CP995.

We offer competitive salaries supported by a substantial range of fringe benefits normally associated with a major international company including relocation assistance where appropriate.

These appointments are open to both men and women.

Please write, quoting the appropriate reference number, with full career and salary details, to: J. Flint, Personnel Manager, FBC Limited, Chesterford Park Research Station, Saffron Walden, Essex CB10 1XL.

*FBC Limited is a subsidiary of Schering AG, West Germany.*



## BIOTECHNOLOGY SALES TRAINEE

New Brunswick are wishing to maintain their success by employing a Sales Trainee. Initially based at Watford during induction on our range of laboratory equipment used in Research and Industrial Laboratories.

New Brunswick's 15 fold expansion in the last five years has created this vacancy to support and share the success of our existing personnel.

More detailed information obtainable from Andrew Buck on (0923) 23293.

**NEW  
BRUNSWICK  
SCIENTIFIC**



## MEDICAL RESEARCH COUNCIL

**Clinical & Population Cytogenetics Unit  
Pattern Recognition & Automation Section**

## Image Analysis

Applications are invited for a CAREER NON-CLINICAL SCIENTIFIC post with the Medical Research Council. The post is tenable at this Unit in the first instance.

The Unit has developed hardware and software solutions to a range of problems in the analysis of scanned microscope images, in cytology and cytogenetics. These have opened up a challenging range of new possibilities including the possibility of fully automatic aberration scoring and aneuploidy detection. Further advances are also envisaged from the increased use of parallel processing techniques (the Unit has both a Clip 4 piped-array processor and multiple 68000 configurations) and the introduction of formal rule systems to guide the analysis process.

The successful applicant will have graduated in mathematics, computer science or a related discipline and will have a convincing record of research in image analysis in the biological sciences. He or she must not only have demonstrated capability for innovation and experiment, but also a capacity for planning, management and execution of substantial application projects.

Remuneration will be at an appropriate point on the scales of university non-clinical academic staff. Further information and an application form may be obtained from The Administrative Officer, Medical Research Council, Clinical & Population Cytogenetics Unit, Western General Hospital, Crewe Road, Edinburgh EH4 2XU with whom applications—including a full CV, publications list, a statement of not more than 500-1000 words describing their proposed research intentions and the names of two professional referees—should be lodged by 3 May, 1985.

## UNIVERSITY OF LIVERPOOL

### 'New Blood' LECTURESHIP IN PURE MATHEMATICS

Applications are invited for the post of Lecturer in the Department of Pure Mathematics, established under the 'New Blood' initiative and tenable from 1 October, 1985. Candidates should normally be aged 35 or under on appointment. Persons holding permanent university appointments in the UK, of whatever kind, are ineligible for appointment to this post. The appointee's teaching duties in the early years will be reduced in favour of research, for which extra financial support is available. Preference will be given to candidates with strong research experience in algebraic group theory or one of its major areas of application, but other well-qualified candidates may be considered.

Initial salary within the range £7520-£12 635 pa on a scale rising to £14 925 pa.

Applications, together with the names of three referees, should be received not later than 7 May, 1985 by The Registrar, The University, PO Box 147, Liverpool L69 3BX, from whom further particulars may be obtained.

Quote Ref: RV/995 (d).

### THE CENTRAL BLOOD LABORATORIES AUTHORITY has a vacancy at its Blood Products Laboratory for a TECHNICIAN

A person is required to join a small team working on projects related to the design of economic fractionation processes for Factor VIII, the prevention of proteolytic degradation of the molecule, and safety aspects of clinical concentrates. Applicants should possess a BSc, or its equivalent, in Life Sciences (preferably Biochemistry); a knowledge of coagulation factors or experience in protein purification would be an advantage.

Remuneration will be commensurate with qualifications and experience. NHS Superannuation scheme applies. Salary range £3761-£8245 pa including a London Weighting Allowance.

For an application form, please telephone Mrs D. Stanton on 01-993 6191, Ext 273 or write to Personnel Department, Blood Products Laboratory, Dagger Lane, Elstree, Herts. Quoting ref BPL/RD/T11.

### UNIVERSITY OF CAMBRIDGE Department of Applied Mathematics and Theoretical Physics

### RESEARCH ON BUBBLES AND DROPLETS IN TURBULENT FLOWS

Schlumberger Cambridge Research (SCR) is sponsoring a research associate to work in the Department of Applied Mathematics and Theoretical Physics with Dr J. C. R. Hunt on mathematical and computer modelling of bubbles and droplets in turbulent pipe flows. The work will be carried out in collaboration with the Fluid Mechanics group at SCR.

Applications are invited from research workers with expertise in theoretical or computational fluid mechanics who have a PhD or are about to complete a PhD in a relevant topic.

Write for further information to: Dr J. C. R. Hunt, Department of Applied Mathematics and Theoretical Physics, Silver Street, Cambridge CB3 9EW, by 15 May, 1985.

## A BETTER CAREER FOR SCIENTISTS

As a medical/technical representative you could utilise your training and experience in a job where career prospects can relate directly to your own efforts. Vacancies arise regularly throughout the UK for trainees, and offer excellent salaries + car + benefits. For further information, phone or write (no stamp needed) for your copy of our free information booklet:

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Freeport, London W2 1HR.

### IMPERIAL COLLEGE OF SCIENCE & TECHNOLOGY Mathematics & Physics Department RESEARCH ASSISTANT

required from October 1985 to work with researchers at Imperial College and RSRE Malvern, on an RSRE funded project for theoretical studies of effects of quantum fluctuations in nonlinear optics. Applicants should have a background in quantum optics and/or quantum statistical theory. The appointment is for one year, with possible extension for a second year.

Salary in the range £8753-£13 383 including London Allowance. The successful applicant will spend equal periods working at RSRE Malvern and Imperial College. Enquiries or applications (cv plus two referees) by 30 April, 1985 to Dr J. N. Eign (Department of Mathematics) or Dr P. L. Knight (Department of Physics) Imperial College, London SW7 2BZ.

The Zoological Society of London  
Institute of Zoology

### LABORATORY TECHNICIAN

required to work in a research programme studying reproduction in seasonally breeding mammals. Applicants should possess or be working towards HNC, BSc or equivalent with a knowledge and interest in reproductive endocrinology. Experience of RIA techniques essential. The appointments, within the MRC/AFRC Comparative Physiology Research Group, is for 18 months. Salary within the range £5520 to £7893 ps inclusive according to age, qualifications and experience.

Applications, with a detailed CV and the names of two referees, should be sent to the Establishment Officer, Zoological Society of London, Regent's Park, London NW1 4RY, to arrive before 2 May, 1985.

### CAMBRIDGE HEALTH AUTHORITY MEDICAL LABORATORY SCIENTIFIC OFFICER

on a two year fixed term contract required by the Department of Clinical Biochemistry in Addenbrookes Hospital.

Applicants must be state registered. Whitley Council salary and conditions of service.

Informal enquiries: Mr D. R. James, Cambridge 246151, Ext. 7154. Job description/application form: Personnel Department, Tel. 246151, Ext. 7511. Closing date 26 April, 1985.

### TROPICAL MARINE RESEARCH UNIT/ UNIVERSITY OF YORK

Temporary Post Doctoral/Post Graduate Research Assistant in Marine Biology for work on

#### OPERATION RALEIGH

Applications are invited for two month volunteer position from 25 April as senior research assistant on coral reef ecology project in Caribbean. All expenses paid. No actual salary.

Candidates must have completed work for PhD or be over 24; min. 3rd Class degree; previous travel/work abroad experience; proven interest in reef biology.

Candidates please phone pre 17 April, Mary Stafford-Smith on York (0904) 5801 Ext 5810, or 42577

### PART-TIME ABSTRACTORS WANTED, acoustics and energy topics, Central London. Brentwood (0277) 224 632.

### APPOINTMENTS WANTED

**EAGER 'A' LEVEL STUDENT** Environmental Science. Biology second employment in Southern Africa/UK in Ecology, Conservation. Qualified Secretary. Box D855.

### STUDENTSHIPS

#### UNIVERSITY OF BRISTOL

**Organic Geochemistry Unit  
RESEARCH STUDENTSHIP**

Applications are invited for a NERC approved PhD Studentship to study, using GLC and GC-MS, the distributions of biological marker compounds such as steroids and porphyrins, released by chemical and thermal degradation of high molecular weight petroleum fractions. The aim is to use these distributions as indicators of thermal history. Candidates should have, or expect to obtain, a good honours degree in Chemistry or Geology.

Applications and further details: Dr J. R. Maxwell, Organic Geochemistry Unit, School of Chemistry, University of Bristol, Bristol BS8 1TS.

### UNIVERSITY OF BRISTOL ORGANIC GEOCHEMISTRY UNIT

Research Studentship (NERC approved CASE award) for marine organic chemistry of biological marker compounds in the NE Atlantic waters. The project is joint with the Marine Biological Association, Plymouth, and seeks to link satellite data with shipboard sampling and laboratory analyses.

Details: Professor G. Eglinton, FRS, University of Bristol, School of Chemistry, Cantock's Close, Bristol BS8 1TS. Tel (0272) 24161, Ext. 623.

### SUNDERLAND POLYTECHNIC

Department of Biology

### NERC RESEARCH STUDENTSHIP

Applications are invited from persons holding or expecting to obtain this summer a first or upper-second class honours degree in a biological science for this NERC-funded post. The position is for three years, and the successful applicant will register for a PhD degree. The research project to be undertaken is in the field of population biology and the work will be supervised by Dr W. Arthur of the Biology Department. The title of the project is "Shell Size and Population Density in Terrestrial Molluscs". Further particulars from, and applications to: Personnel Officer, Langham Tower, Sunderland Polytechnic, Rythope Road, Sunderland SR2 7EE. Deadline for receipt of applications: 6 May, 1985.

### UNIVERSITY OF ABERDEEN

#### DEPARTMENT OF GEOGRAPHY

Applications are invited for a three-year NERC Research Studentship beginning in October 1985, entitled *Modelling the Growth and Decay of the Former British Ice Sheet*. The project involves collaboration with Dr W. F. Budd and a 6-9 month visit to the Department of Meteorology, University of Melbourne, Australia. The approach to the project will depend on the successful candidate. Initially the work could focus on Scotland, where the critical phases of growth and the last phases of decay occurred, and could involve fieldwork in order to assist in calibrating and testing the model. For further information please write to: Dr David E. Sugden, Department of Geography, University of Aberdeen, Aberdeen, AB9 2UF.

### UNIVERSITY OF WALES COLLEGE OF MEDICINE

Department of Medicine

#### MRC RESEARCH STUDENTSHIP—OCTOBER 1985

Applications are invited for the above position from final year students who expect to graduate with a 1st or Upper 2nd Class Honours Degree in the Biological Sciences this summer. The successful candidate will work with a group involved in studies on Autoimmune Thyroid Disease, using expertise in Biochemistry, Immunology and Molecular Biology.

Applicants should send a cv and the names of two referees, as soon as possible to Dr A. M. McGregor, Department of Medicine, University of Wales College of Medicine, Heath Park, Cardiff CF4 4XN. (Tel 0222-755944, Ext. 3480).

### KING'S COLLEGE LONDON (KQC) (University of London)

Department of Anatomy and Human Biology

#### PHD STUDENTSHIPS

Applications are invited for studentships available from October 1985. Applicants should have or expect to have a good Honours degree in a Biological Science, and an interest in one of the following areas: 1. Neuroscience (adult and developing nervous system). 2. Developmental Biology and Reproduction. 3. Genetics (inborn errors of metabolism). 4. The Cell Cycle and Cell Ageing. 5. Human Gait and Posture.

For further details and application form, contact Professor K. E. Webster, Department of Anatomy and Human Biology, King's College London, Strand, London WC2R 2LS. Tel 01-836 5454.

### THE CITY UNIVERSITY School of Electrical Engineering and Applied Physics

#### SERC CASE Studentship FIBRE OPTIC TEMPERATURE SENSING

Applications are invited from students in physics, chemistry, electronic engineering or a related subject for an SERC CASE Studentship in association with the Optical Sensors Collaborative Association (OSCA). London, to develop and study non-linear optical techniques for distributed fibre optic temperature sensing applications. OSCA is a body which brings together most major UK fibre optics field and the student appointed would have a wide access to such firms and their expertise.

Applicants should have for expect to have a First or Upper Second Class Honours degree or an equivalent qualification. Research studentships are also available for suitably qualified graduates in the following areas: Control Engineering Centre, Measurement and Instrumentation Centre, Centre for Information Technology, Centre for Computing and Information in Medicine, MSc Programme in Information Engineering.

For further information, please contact Dr K. T. V. Gratian, School of Electrical Engineering and Applied Physics, The City University, Northampton Square, London EC1V 0HB. Tel 01-253 4399, Ext. 4416.

### UNIVERSITY OF BRISTOL

Department of Geography and Remote Sensing Unit

Invite applications for the following NERC RESEARCH STUDENTSHIPS

One Award - Remote sensing of geological lineaments of important aquifers in the UK. (Dr H. A. Cernanston)

Two Awards - Storage and water movement in the saturated zone of the Mendip Limestone Aquifer (CASE award with Wessex Water Authority and Bristol Waterworks Ltd) (Dr P. S. Selverstone)

Slope stability in sub-tropical and tropical areas (CASE award with Ove Arup and Partners). (Dr M. G. Anderson)

The use of passive microwave data in satellite-improved rainfall monitoring. (Dr E. C. Barrett)

Morphoclimatological concepts and statistics for satellite-assisted monitoring of rainfall and drought over Africa. (Dr E. C. Barrett)

Enquiries should be directed to the project supervisor named above not later than the 19 April, 1985, at the following address: Department of Geography, University of Bristol, Bristol, BS8 1HS.

### UNIVERSITY OF ST ANDREWS

#### MRC ADVANCED COURSE STUDENTSHIPS

Applications are invited for the above studentships for the MSc Course in Radiation Biophysics. The course is interdisciplinary and run jointly by the Departments of Anatomy and Experimental Pathology and Physics. It is structured to accommodate those qualified either in the physical sciences and caters for differing interests and career intentions of students.

Enquiries and applications to Dr A. C. Ritchie, Department of Anatomy and Experimental Pathology, University of St Andrews, St Andrews, Fife KY16 9TS.

# THE UNIVERSITY OF MANCHESTER

**Department of Chemistry**  
**SERC CASE STUDENTSHIP IN THEORETICAL CHEMISTRY**  
 Applications are invited for a CASE studentship in the development and use of accurate molecular orbital calculations of metal-ligand interactions to study problems relevant to heterogeneous catalysis, in collaboration with ICI New Science Group. Candidates should have a good honours degree in Chemistry or Physics. Further information may be obtained from Professor I. H. Hillier, Department of Chemistry, The University, Manchester M13 9PL.

## SERVICES

**FOR ALL TECHNICAL TRANSLATIONS FROM JAPANESE** contact Ingatstone Translations, 57 High Street, Ingatstone, Essex CM4 0AT. Tel (0277) 353863 and 354022.

## FELLOWSHIPS, GRANTS & SCHOLARSHIPS

### MAX-PLANCK-INSTITUTE FOR BIOPHYSICS

Postdoctoral Research Fellowship in  
**BIOPHYSICS**

Characterization of polydisperse lipid systems by photon correlation spectroscopy.

Applications are invited from candidates interested in joining a multi-disciplinary research group studying transport processes in membranes. The fellowship is offered for a one to two year period starting May 1985 or later. Salary will be from DM 25,000 to DM 32,000 p.a., net, depending on experience. Send application (cv, list of publications, names of two referees) to Dr E. Grel, Max-Planck-Institut für Biophysik, Heinrich-Hoffmann-Str. 7, 6000 Frankfurt 71, (West Germany).

### KING'S COLLEGE LONDON (KQC)

(University of London)

### POSTDOCTORAL RESEARCH FELLOWSHIP IN FIBRE-OPTICS

Applications are invited for a three year postdoctoral research fellowship funded by SERC under the JOERS scheme to investigate nonlinear interaction in optical fibres.

Applicants have pursued PhD research in a relevant area of solid state optics or opto-electronics or have recent industrial experience in optical fibre research.

Applications should be sent to Professor C. W. Turner, Department of Electronic and Electrical Engineering, King's College London, Strand, London WC2R 2LS.

### UNIVERSITY OF EDINBURGH

Department of Respiratory Medicine

Applications are invited for a

### FACULTY OF MEDICINE RESEARCH SCHOLARSHIP

to work on aspects of the control of breathing in humans with opportunity to study for a PhD Degree. Applicants applications should include in respect to obtain a 1st or 2nd Honours Degree in a physiological science. Further information may be obtained from Professor D. C. Flenley, Department of Respiratory Medicine, City Hospital, Greenbank Drive, Edinburgh EH10 5SB to whom applications including curriculum vitae and names and addresses of two referees should be sent by 3 May.

# Travelling Fellowships 1986/87

The Medical Research Council's Travelling Fellowship scheme enables clinical and non-clinical biomedical research workers to undertake advanced specialised training overseas for a period of three months to one year.

Applications are now invited from suitable qualified candidates for awards to be taken up in Autumn 1986.

## Eligibility Requirements:

**Graduates in medicine or dentistry** should be of NHS Registrar/Senior Registrar Status (or academic equivalent) with some research experience.

**Graduates in science** should hold a PhD/DPhil degree and normally have had at least two years' post-doctoral research experience.

*Applications cannot be accepted from candidates already overseas who wish to extend their stay.*

**MRC**  
 Medical Research Council

Further details and application forms are available on request from the Medical Research Council, Training Awards Group, 20 Park Crescent, London W1N 4AL. Closing date for receipt of applications: 30 September 1985. Late applications will not be accepted.

### UNIVERSITY OF NOTTINGHAM

Department of Chemistry  
**POSTDOCTORAL RESEARCH FELLOWSHIP**

Laser Photodissociation Dynamics

Applications are invited for an SERC Postdoctoral appointment to undertake research in collaboration with Professor J. P. Simons on the dynamics of molecular photodissociation, using high intensity, pulsed laser excitation techniques. The appointment is tenable from September/October 1985 for two years at a starting salary up to £7980 p.a. + USS (under review). Familiarity with pulsed excimer and dye laser and/or computing and/or molecular beam techniques would be helpful.

Applications including full cv and naming two referees should be sent as soon as possible to Professor J. P. Simons, Chemistry Department, The University, Nottingham NG7 2RD.

### KENT COUNTY COUNCIL EDUCATION COMMITTEE MID-KENT COLLEGE OF HIGHER AND FURTHER EDUCATION

Department of Science  
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The post is available for two years, with a starting salary within the NJC (8) Scale £7649-£10,251.

Applications, accompanied in each case by a cv and the names of two referees should be sent to the Principal, Mid-Kent College of Higher and Further Education, Horsted, Chatham, Kent ME5 8UG, by Friday 3 May, 1985.

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## University of Reading

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The course is open to graduates in physics, mathematics or engineering. Students with recognised equivalent qualifications may also be admitted. Studentships are available for suitable applicants, and opportunities exist for research leading to the PhD degree.

Further details may be obtained from Professor H. H. Hopkins, FRS, Department of Physics, The University, Whiteknights, Reading RG6 2AF.

### UNIVERSITY OF DURHAM

#### Department of Botany MSc BIOTECHNOLOGY

This new one-year course (starting 27 September, 1985) results from collaboration between the Department of Botany and Imperial Chemical Industries PLC. The course, which combines lectures and practicals with a research project, will provide an overview of modern concepts and techniques in biotechnology. Topics include: techniques in molecular biology and cell biology; genetic engineering of eukaryotes; tissue culture and monoclonal antibodies; industrial microbiology; fermentation and chemical engineering; microbial leaching and metal stripping; enhanced oil recovery and degradation; air and micro-organisms; biomass conversion; novel plant products; legal and regulator aspects.

Instruction will include a significant contribution from ICI staff, especially from Biological Products Business at Billingham. The course is especially suitable for biological chemists, microbiologists, botanists and applicants from related disciplines, and will also offer a rapid and efficient retraining programme for applicants seconded from industry. Application forms and further particulars may be obtained from Dr B. A. Whitton, MSc Biotechnology, University of Durham, Durham DH1 3LE, England.

Air '85

23-25 September 1985

### Advances in Fermentation 1985

A three-day conference on 'Advances in Fermentation' will be held in London, England from 23 September to 25 September, 1985. This is a natural successor to the Conference on 'Advances in Fermentation' held in 1983. As with the previous event, it is being arranged at the kind invitation of Professor H. Baun of the Department of Biochemistry of the New King's College London, (KOC).

- Conference Sessions
- Conversations
- Posters
- Exhibition

Details from Air '85, c/o Process Biochemistry, Penn House, Rickmanworth, Herts, United Kingdom WD3 1SN.

### THE PURSUIT OF KNOWLEDGE: RULES, ROLES AND RELATIONSHIPS

A One-Day Conference on Monday 15 April, 1985 at King's College London.

(Previously advertised as being held at the Royal Institution of Great Britain).

Leading scholars from Britain and America take a searching look at the current state of ethical standards in the practice of science.

Further information and application forms available from Professor I. Kennedy, Centre of Medical Law and Ethics, King's College London, Strand, London WC2R 2LS. Tel: 01-836 5454, Ext 2449, 2361 or 2179.

### UNIVERSITY COLLEGE OF WALES AND RSC MID WALES

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Tuesday, 17 September, 1985

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Symposium Secretary:  
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# ARIADNE

**H**ANG ON a minute before you buy yourself a Sceptre telephone from British Telecom. The machine is, of course, push button, so like most push button telephones, will take much longer to start a number ringing the other end, or it seems to, admittedly a subjective reaction. On the other hand, most telephone users are pretty subjective, I find.

We are all proud of our STD system. Heavens, you can call all over the country or a great part of the very globe itself, without bothering an exchange. The Sceptre telephone will display the number you have called, so you can see if you have made a mistake or "misdialled" as the old phrase has it. Better still, the Sceptre has memory and you can reach a number out of it to be displayed, too.

So you can, but only sort of, know what I mean? The display is limited to eight digits. So, if you are calling a London number from out of town, the 0 will disappear off to the left. You can always allow for that, I suppose, or even 01. But what if you want a number that is a 10-digit one and not a London code? What if, worse you are calling an international number? Best to use a pencil and paper or rely on your own short-term memory.

Still, the Sceptre has a long-term one, so all may not be lost, as the saying goes. It will happily store much longer numbers and display them for you. Well, sort of, you know? It is the really long numbers that you are likely to make a mistake on, so as such a number builds up past the eight character length, the digits will disappear, stage left, like players in Haydn's Farewell Symphony. Perhaps a way of getting over this is to store an international number in eight-digit lengths and push several buttons instead of one to recall it. Incidentally, the number displayed in BT advertisements for Sceptre is an eight-digit one, from its own information series.

While we are at it, be a bit cautious about buying an answering machine from British Telecom. BT will deliver the machine and hand it over to you in its box. If you should, by some remarkable chance, want it installed, that will entail another visit. □

**I**T IS hard sometimes to know whether you are on your elbow or the part of the anatomy referred to colloquially by the Bishop of Durham in a recent speech. There are ideas of storing nuclear waste in deep underground strata, after investigation of the suitability of the site and, of course, with the waste, low-level, being placed in containers. To get a move on, the Environment Secretary, Patrick Jenkin, has vetoed public inquiries before any test drilling can be done. "A totally outrageous move," said the director of Greenpeace, Peter Wilkinson, "although it is quite typical of this government's unholy haste to get rid of the problem of nuclear waste disposal."

I offer no comment on that, except that I should have thought that the haste, holy or unholy, might have been to get rid of the waste, not the problem. □



The reason I am a little confused is that a month before all this, members of Greenpeace dumped five tonnes of radioactive mud on the steps of the Department of the Environment, possibly putting people at large at some risk from radiation without their knowledge. □

**C**HANGE the daily routine of a dog or a cat and you may be in for trouble, the British Small Animal Veterinary Association says. You may put a dog's snout out of joint if you bring in a pup, for instance, or you may find that if you leave an animal alone in the house, it will start chewing the furniture or ripping paper to shreds.

So far so good, but when the association gets on to advice, it becomes a bit murky. If you were moving house, say, what would you conclude you ought to do about your dog or cat or hamster when advised to "plan in advance, think about the best way to tackle the change in such a way that your pet has as long a period of transition as possible..."? □

**T**HE USUAL cries of outraged pomposity, I see, broke out when the Department of Energy issued a press release, dated 1 April, on the thermal necktie to conserve heat for those who lose it through the area of the sternum. Full marks, I reckon, to the civil servants who maintain a sense of humour, against the odds. I hope nobody was threatened with the sack by the solemn idiots who are there all right in the department, as they are everywhere.

At least those who read the handout knew where they were. Government handouts are occasionally hard to fathom. Is a sense of humour involved or not? For example, a recent missive from MAFF, the Ministry of Agriculture, Fisheries and Food, about revising the system of livestock quality controls said that the emphasis would be shifted in favour of informed consumer choice (they can't mean the cows, can they?), and that equal information would be required to be displayed for all approved bulls. □

And stand up straight when I'm interacting with you

**C**ELL mitochondria are the "power-houses" of biochemistry. These little enzyme-packed granules, which these days can easily be extracted from bacterial cells, do most of the oxidation for the cell. Daedalus is now harnessing them to human need. His "biological hot-water bottle" is a silicone-rubber bag filled with a suspension of mitochondria in a solution of the archetypal biochemical fuel, glucose.

Silicone rubber is permeable to oxygen and carbon dioxide, so atmospheric oxygen will diffuse into the bag and start oxidising the glucose under mitochondrial control. A few added enzymes and promoters may be needed to take the process to its ultimate end-product of carbon dioxide, which will diffuse out of the bag again. The heat of reaction will warm the whole thing up.

At first, Daedalus feared that the solution would soon boil, bursting the bag. But he soon realised that enzymes are heat-sensitive, and "switch off" at some critical temperature, thus thermostating the bag at that temperature. Mitochondria from hot-spring-dwelling bacteria, for example, should thermostate the bag at their optimum operating temperature of about 40°C.

This wonderful self-powered hot-water bottle could be "turned off" at any time by slipping it into a plastic bag, thus shutting off its oxygen supply and temporarily "suffocating" it. A 1-litre bottle, good for 100 hours of continuous heat, should last about a fortnight as a nocturnal bed-warmer before needing more glucose. Other comfort applications include Daedalus's "biological boot" for effortlessly warming feet, his "hydraulic hot pants" (with a useful cushioning effect when you sit down), the self-warming sofa, and so on. Furthermore, if mitochondria from luminous bacteria were added to the mix, the new products would glow gently all the time from within. Self-warming and luminous cushions or upholstery would enhance any domestic scene. A luminous hot-water bottle would greatly simplify the cosy delights of reading under the bedclothes. □

THE COMET IS COMING!



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**H**ALLEY'S COMET will become visible in our skies next year as it approaches the Earth on its 76-year orbit. In the past, the comet's visits have provoked all kinds of reactions, ranging from scientific curiosity to superstitious panic. Astronomers wanting to study the comet were limited by the observing facilities available to them; and of course their telescopes were on the ground. Now, for the first time, astronomers can observe Comet Halley at close quarters by means of spacecraft which can fly past the comet and send back to Earth detailed information on its composition.

In July, the European Space Agency will launch its Giotto spacecraft. The mission is intended to encounter the comet in March 1986 and to skim past its nucleus. Information from Giotto, together with data from the American, Soviet and Japanese missions to Comet Halley, will be used by astronomers throughout the world to build up a detailed picture of the comet.

The European Space Agency is offering a trip to its launch site in Kourou (French Guiana) for the launch of Giotto as first prize in a competition sponsored by the Science and Engineering Research Council, *New Scientist* and the British Association Young Scientists.

Write an essay describing either:

—how you plan to observe Halley's Comet, and what sort of experiment(s) and observations you would carry out if you had

access to scientific facilities (optical, infrared or radio telescopes, interplanetary probes, and so on)

or:—some aspect of the history of Comet Halley's appearances and the various reactions to it—popular reaction, earlier scientific studies and so on.

The competition is open to anyone aged between 13 and 20 on 1 July 1985. The writer of the winning entry (the judges will take entrants' ages into account) will be offered a trip to Kourou for the Giotto launch, and the ten runners-up will receive a year's subscription to *New Scientist*. The writers of the best two essays will also receive free invitations to attend the Glasgow meeting of the British Association for the Advancement of Science in August. The names of the first and second prizewinners will be announced in *New Scientist* on 6 June, and provided the winning entry is of sufficient merit it will be published in this journal.

Entries should be typed or written in English, using only one side of the paper and double-line spacing. On the top left-hand corner of the first page give your full name and address and date of birth. Put your name on every sheet. The competition closes on 16 May 1985.

Post your entry to Karen Iddon, Room 114, *New Scientist*, Commonwealth House, 1-19 New Oxford Street, London WC1A 1NG.

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